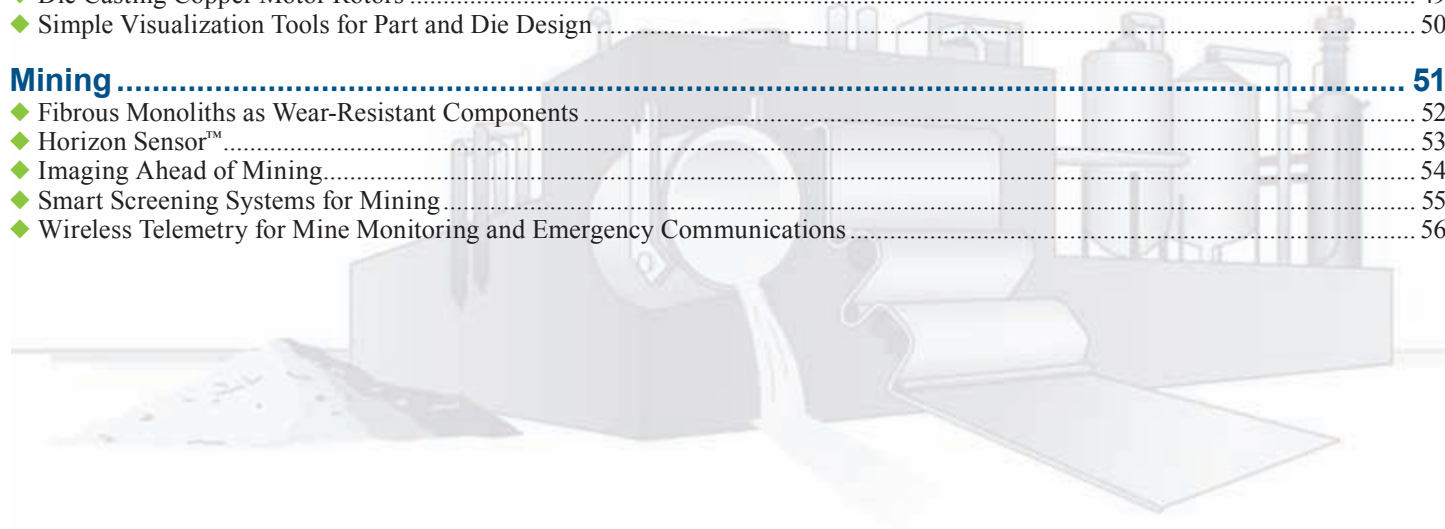


Appendix 1:

ITP-Sponsored Technologies Commercially Available

Aluminum	13
◆ Aluminum Reclaimer for Foundry Applications	14
◆ Aluminum Scrap Decoater	15
◆ Aluminum Scrap Sorting	16
◆ Detection and Removal of Molten Salts from Molten Aluminum Alloys	17
◆ Oxygen-Enhanced Combustion for Recycled Aluminum	18
◆ Recycling of Aluminum Dross/Saltcake Waste	19
Chemicals	21
◆ Aqueous Cleaner and CleanRinse™ Recycling System	22
◆ DryWash®	23
◆ Dual-Cure Photocatalyst	24
◆ Micell Dry-Cleaning Technology	25
◆ No-VOC Coating Products	26
◆ Powder Paint Coating System	27
◆ Pressure Swing Adsorption for Product Recovery	28
◆ Supercritical Purification of Compounds for Combinatorial Chemical Analysis	29
◆ Ultrasonic Tank Cleaning	30
◆ Use of Recovered Plastics in Durable Goods Manufacturing	31
◆ Water-Washed Overspray Paint Recovery	32
Forest Products	33
◆ Chemical for Increasing Wood Pulping Yield	34
◆ Continuous Digester Control Technology	35
◆ Detection and Control of Deposition on Pendant Tubes in Kraft Chemical Recovery Boilers	36
◆ Improved Composite Tubes for Kraft Recovery Boilers	37
◆ METHANE de-NOX® Reburn Process	38
◆ Optimizing Tissue Paper Manufacturing	39
◆ Pressurized Ozone/Ultrafiltration Membrane System	40
◆ Thermodyne™ Evaporator – A Molded Pulp Products Dryer	41
◆ XTREME Cleaner™ – Removal of Light and Sticky Contaminants	42
Glass	43
◆ Advanced Temperature Measurement System	44
◆ High Luminosity, Low-NO _x Burner	45
◆ Oxygen-Enriched Air-Staging (OEAS) Technology	46
Metal Casting	47
◆ Ceramic Composite Die for Metal Casting	48
◆ Die Casting Copper Motor Rotors	49
◆ Simple Visualization Tools for Part and Die Design	50
Mining	51
◆ Fibrous Monoliths as Wear-Resistant Components	52
◆ Horizon Sensor™	53
◆ Imaging Ahead of Mining	54
◆ Smart Screening Systems for Mining	55
◆ Wireless Telemetry for Mine Monitoring and Emergency Communications	56



ITP-Sponsored Technologies Commercially Available

IMPACTS

Steel	57
◆ Automatic High-Temperature Steel Inspection and Advice System	58
◆ Dilute Oxygen Combustion System	59
◆ Electrochemical Dezincing of Steel Scrap	60
◆ Laser Contouring System for Refractory Lining Measurements	61
◆ Microstructure Engineering for Hot Strip Mills	62
◆ Recovery of Acids and Metal Salts from Pickling Liquors	63
◆ Shorter Spheroidizing Annealing Time for Tube/Pipe Manufacturing	64
◆ Steel Reheating for Further Processing	65
◆ Transfer Rolls for Steel Production	66
Crosscutting	67
◆ Callidus Ultra-Blue (CUB) Burner	68
◆ Catalytic Combustion	69
◆ Chemical Vapor Deposition Optimization of Ceramic Matrix Composites	70
◆ Energy-Conserving Tool for Combustion-Dependent Industries	71
◆ Evaporator Fan Controller for Medium-Temperature Walk-In Refrigerators	72
◆ Fiber-Optic Sensor for Industrial Process Measurement and Control	73
◆ Fiber Sizing Sensor and Controller	74
◆ Foamed Recyclables	75
◆ Forced Internal Recirculation Burner	76
◆ Freight Wing™ Aerodynamic Fairings	77
◆ High-Temperature Radiant Burner	78
◆ Improved Diesel Engines	79
◆ Infrared Polymer Boot Heater	80
◆ In-Situ, Real Time Measurement of Melt Constituents	81
◆ Materials and Process Design for High-Temperature Carburizing	82
◆ Method of Constructing Insulated Foam Homes	83
◆ Mobile Zone Optimized Control System for Ultra-Efficient Surface-Coating Operations	84
◆ Nickel Aluminide Trays and Fixtures Used in Carburizing Heat Treating Furnaces	85
◆ PowerGuard® Photovoltaic Roofing System	86
◆ Process Particle Counter	87
◆ Radiation-Stabilized Burner	88
◆ Real-Time Neural Networks for Utility Boilers	89
◆ RR-1 Insulating Screw Cap	90
◆ Solid-State Sensors for Monitoring Hydrogen	91
◆ SpyroCor™ Radiant Tube Heater Inserts	92
◆ SuperDrive – A Hydrostatic Continuously Variable Transmission (CVT)	93
◆ Thin Wall Casting of Stainless Steel	94
◆ Ultra-Low NO _x Premixed Industrial Burner	95
◆ Uniform Droplet Process for Production of Alloy Spheres	96
◆ Uniformly Drying Materials Using Microwave Energy	97
◆ Variable-Frequency Microwave Furnace	98
◆ Waste Fluid Heat Recovery System	99
◆ Waste-Minimizing Plating Barrel	100
Other Industries	101
◆ Absorption Heat Pump/Refrigeration Unit	102
◆ Advanced Membrane Devices for Natural Gas Cleaning	103
◆ Brick Kiln Design Using Low Thermal Mass Technology	104
◆ Continuous Cascade Fermentation System for Chemical Precursors	105
◆ Energy-Efficient Food Blanching	106
◆ Ink Jet Printer Solvent Recovery	107
◆ Irrigation Valve Solenoid Energy Saver	108
◆ Restaurant Exhaust Ventilation Monitor/Controller	109
◆ Stalk and Root Embedding Plow	110
◆ Textile Finishing Process	111
◆ Utilization of Corn-Based Polymers	112

IMPACTS

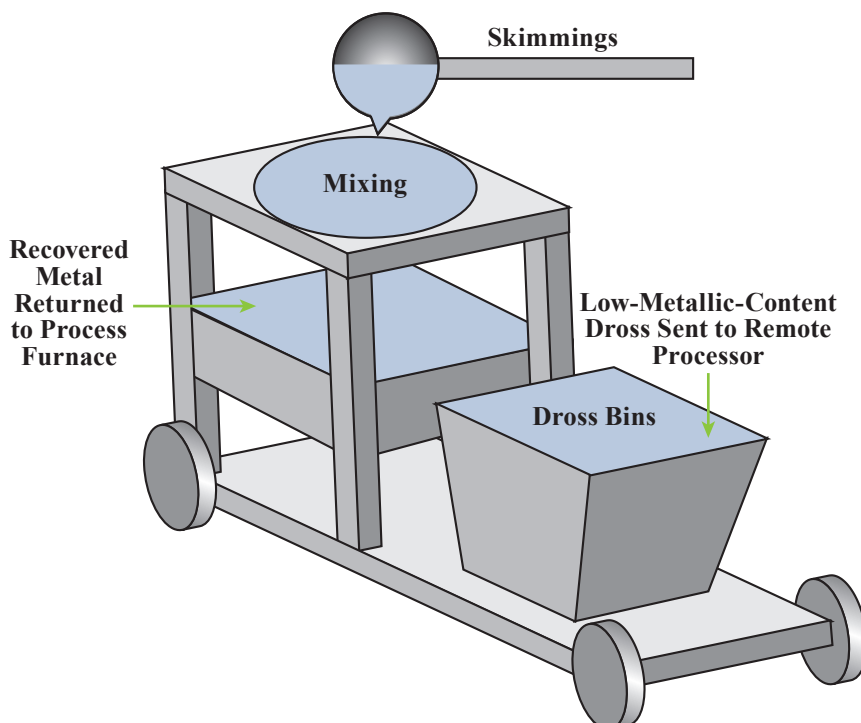
- ◆ Aluminum Reclaimer for Foundry Applications..... 14
- ◆ Aluminum Scrap Decoater 15
- ◆ Aluminum Scrap Sorting..... 16
- ◆ Detection and Removal of Molten Salts from Molten Aluminum Alloys17
- ◆ Oxygen-Enhanced Combustion for Recycled Aluminum 18
- ◆ Recycling of Aluminum Dross/Saltcake Waste..... 19



Affordable Metallic Recovery System Saves Energy and Reduces Landfill Waste Streams

Aluminum foundries and melters typically generate metallic skimming and drosses during industrial processes. While equipment is commercially available to recover a portion of the contained metallics from skimmings and drosses, the capital investment for the equipment has precluded its application with smaller melting units such as crucible or reverb melters. With assistance from DOE's Industrial Technologies Program, Q.C. Designs, Inc., developed an improved reclaiming process specifically to recover the metallics from small quantities of dross and skim. Recent advances in the technology permit an increase in the quantity of drosses being processed and allow the recovered metal to be returned to the generating furnace in molten form, in some cases. The process has recovered as much as 80% of the contained metal at the point of generation.

In operation, the process may be run either manually, with power-assisted stirring, or with a fully automatic programmed cycle. The operation is environmentally friendly reducing the amount of smoke and fumes normally associated with dross processing and furnace cleaning. Foundries reduce their melting losses by the in-plant recovery of drosses and their contained metals, which can then be reused directly without realloying.



Portable Aluminum Reclaimer

Overview

- ◆ Available from Q.C. Designs, Inc.
- ◆ Commercialized in 2001
- ◆ Six units installed in the United States

Applications

In-plant aluminum foundry dross and skimming recovery

Capabilities

- ◆ Processes hot dross in quantities from 20 to 500 lb.
- ◆ Allows automatic processing or manual operation.
- ◆ Features sizes for applications in different foundry installations.

Benefits

Energy Savings

The recovered metal from the new system may be reintroduced into the process in molten form, saving the energy required to remelt an ingot recovered in a traditional process. Less energy is required to transport and move the dross to an outside processor because the system is on-site, and the material does not have to be remelted for secondary recovery of the metallics.

Productivity

The improved ability to decrease melting losses contributes directly to profits. Typical compensation for dross materials from outside processors is 10% to 20% of true value because the generating foundry has to bear the costs of transportation, remelt and processing, landfill of the waste, and return of the recovered material. In-plant processing eliminates most of these costs.

Waste Reduction

The technology avoids sending process salts to landfills and recovers a higher percentage (up to 80%) of metallics than current methods.

IMPACTS

Indirect-Fired Kiln Turns Aluminum Scrap into Valuable Feedstock

Through a grant from DOE's NICE³ Program, Energy Research Company has further developed and demonstrated an innovative aluminum-scrap melting process. This process uses an indirect-fired controlled-atmosphere kiln to remove machining lubricants, oils, and other materials from the scrap aluminum. Once removed, these materials are combusted in an afterburner, destroying all volatile organic compounds (VOCs) and releasing heat used to drive the process.

This innovation de-coats scrap aluminum parts in a controlled atmosphere with limited oxygen to avoid scrap-oil combustion and scrap oxidation. The resulting gases are then combusted in an incinerator, apart from the scrap, to destroy the volatile organic compounds. The heat released from this atmospheric combustion drives the de-coating process. There are currently 3 units operating in the United States and an additional 15 worldwide.

Benefits

Energy Savings

Energy savings of 55% over conventional kiln decoating.

Environmental

Reduces solid-waste disposal needs because of reduced dross and oxidized product.

Productivity

Improved product quality and reduced material loss due to better process control.

Overview

- ◆ Developed by Energy Research Company
- ◆ Commercialized in 1997
- ◆ 3 units operating in the United States in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
1.17	0.378

Emissions Reductions

(Thousand Tons, 2004)

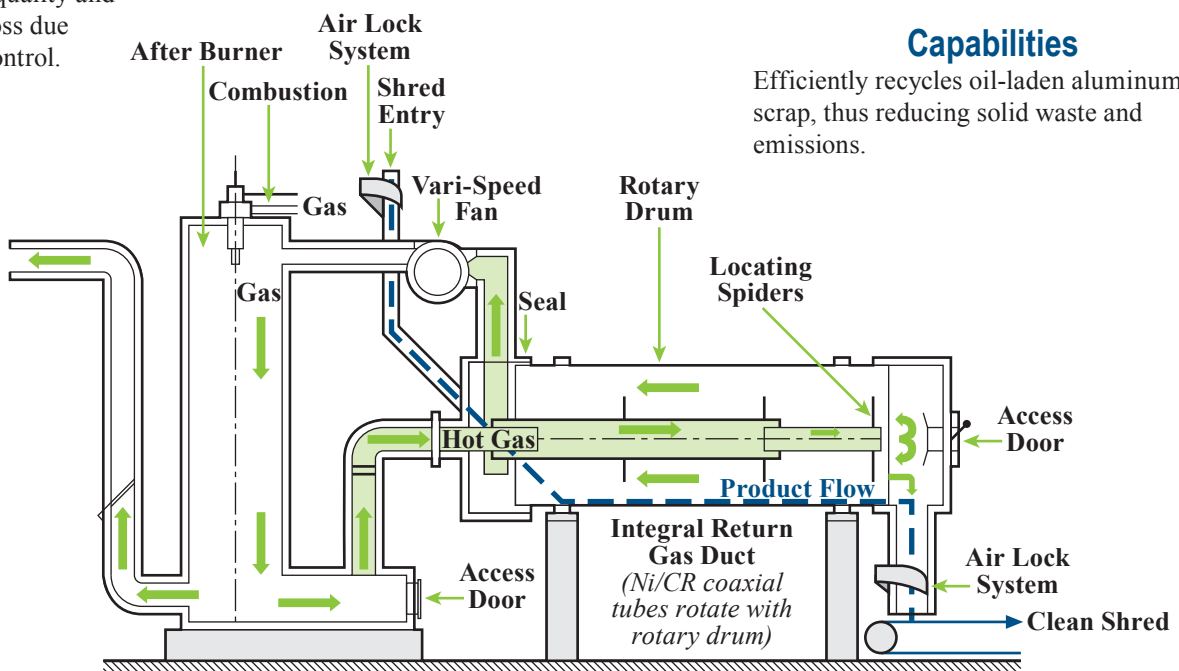
Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.044	6.00

Applications

- ◆ The secondary aluminum industry that processes scrap from the manufacturing process and used aluminum
- ◆ May also be used when processing other materials with organic binders or coatings, such as fiberglass recycling

Capabilities

Efficiently recycles oil-laden aluminum scrap, thus reducing solid waste and emissions.



Aluminum Scrap Decoater

Effective Scrap Sorting Provides Large Energy Benefits

Huron Valley Steel (HVS) Corporation has developed new scrap sorting technologies, and with support from ITP, they demonstrated that aluminum scrap from aluminum-intensive vehicles can be recycled. The HVS technology assesses the composition and material recovery from the sorting steps required to produce alloy-sorted aluminum from mixed-alloy scrap. A proprietary HVS technology is used for wrought-cast separation. After the wrought fraction is tint-etched, color sorting groups the wrought iron alloys. Laser induced breakdown spectroscopy is used for real-time, remote chemical analysis of each scrap particle and allows the sorting line to separate individual alloys.

This particle-sorting technology focuses on demonstrating the capability to sort nonferrous metal scrap from the reusable materials from aluminum-intensive vehicles. The process includes physical property sorting and chemical composition sorting and is capable of real-time, piece-by-piece batching of specific alloy compositions from the analyzed scrap. This process will help improve the melt composition of recycled materials and is more efficient and less energy intensive than existing chlorination, fractional solidification, and electro-refining processes.

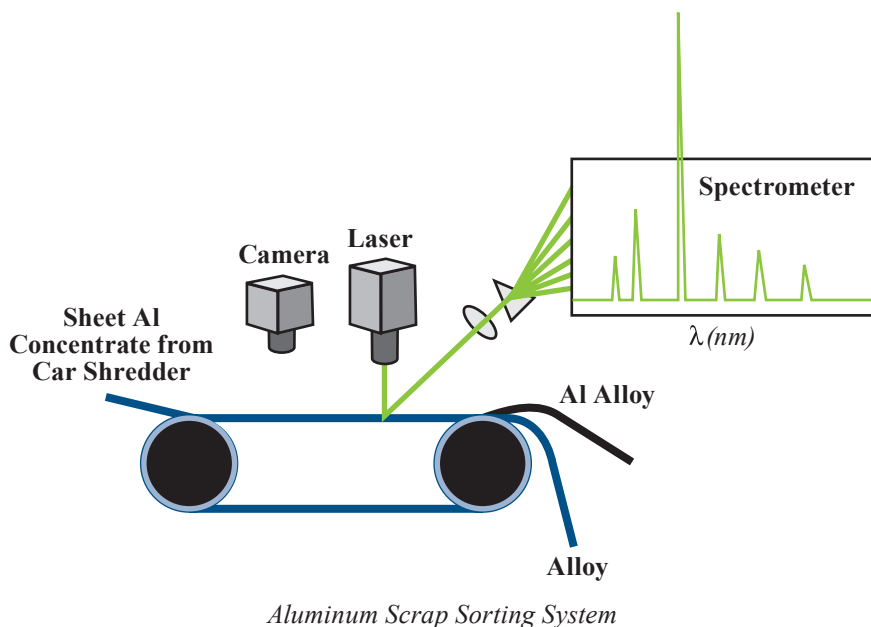
Benefits

Environmental

Using aluminum that otherwise would have been scrapped decreases the production of prime metal and thereby reduces greenhouse gas emissions.

Use of Raw Materials/Feedstocks

The process can eliminate a portion of raw aluminum production and any other alloys that the process is applied to.



Overview

- ◆ Developed by Huron Valley Steel Corporation
- ◆ 7500 tons of sorted product processed in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.698	0.338

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.002	0.073	0.054	6.63

Applications

- ◆ Sorting of mixed aluminum scrap streams
- ◆ Sorting of vehicle and other equipment scrap streams

Capabilities

- ◆ Improves sorting of mixed aluminum scrap streams.
- ◆ Allows aluminum from scrapped motor vehicles to be separated and used as high value aluminum alloys.
- ◆ Separates cast aluminum from wrought, groups aluminum into alloy families, and differentiates between wrought alloys.

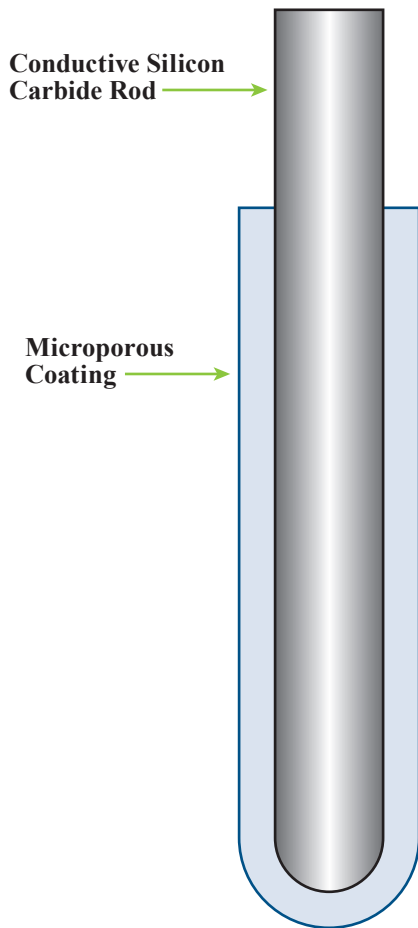
Detection and Removal of Molten Salts from Molten Aluminum Alloys

IMPACTS

New Probe and Filter Will Improve Metal Quality Through Detection and Removal of Impurities

With assistance from DOE's Inventions and Innovation Program, Selee Corporation and the Alcoa Technical Center have developed and commercialized this technology to detect and reduce chloride salts in molten aluminum. These salts have been shown to initiate defects when they agglomerate and migrate to the surface of an ingot or casting. Because they are liquid at aluminum casting temperatures, they can pass through conventional filter systems, which are designed to capture solid inclusions. Moreover, they tend to reduce the efficiency of filters by causing the release of solid inclusions.

The operation principle of the salt probe and filter is based on interfacial surface phenomena between the various liquid phases (salt and aluminum) and the solid salt system material. The probe is made up of a thin, microporous, ceramic layer that is coated onto an electrically conductive silicon carbide rod. The rod is immersed into the molten aluminum and a potential difference is applied to the probe. Salt can penetrate the coating on the probe and, due to the ionic nature of the salt, an electrical current that can be measured is formed. The filter also uses microporous ceramic to separate the salts from the liquid aluminum.



Salt Probe

Overview

- ◆ Developed by Selee Corporation and the Alcoa Technical Center
- ◆ 2 units are in operation in the United States and Canada
- ◆ Commercialized in 1999

Applications

The technology will improve metal quality by detecting and removing impurities and inclusions from molten aluminum

Capabilities

The technology will improve metal quality by detecting and removing impurities and inclusions from molten aluminum

Benefits

Energy Savings

Elimination of melt rejection and recast due to salt contamination, with potential annual energy savings of 0.04 trillion Btus.

Productivity and Cost

Estimated reduction in chlorine use and release of about 71,000 cubic feet per year.

Product Quality

Improved metal quality, recovery, and reliability.

Oxygen-Enhanced Combustion for Recycled Aluminum

IMPACTS

New Metal Melting System Results in Low NO_x Emissions, Reduced Energy Use, and Increased Productivity

With ITP support, Air Products & Chemicals, Inc., in cooperation with Argonne National Laboratory, Wabash Alloys, L.L.C., and Brigham Young University, developed and demonstrated a low-NO_x combustion burner integrated with an onsite vacuum-swing-absorption (VSA) oxygen-generation system. This new burner, operated at the Wabash Alloy recycled aluminum furnace, used controlled mixing of fuel, air, and high-purity oxygen streams to lower emissions and improve flame quality.

The VSA system uses a patented high-efficiency molecular sieve to remove nitrogen from the air. Conventional VSA plants are sized for peak demand, and the excess oxygen is vented to the air during off-peak operation. In this application, the oxygen VSA is improved to operate with a sieve-filled storage vessel that stores oxygen produced when demand is below the average oxygen requirement. The sieve-filled vessel provides 2.5 times the oxygen storage capacity of an empty tank of equal volume. The integration of the new burner with the VSA system greatly reduces NO_x emissions while reducing energy usage and increasing melting productivity.

Benefits

Cost Savings

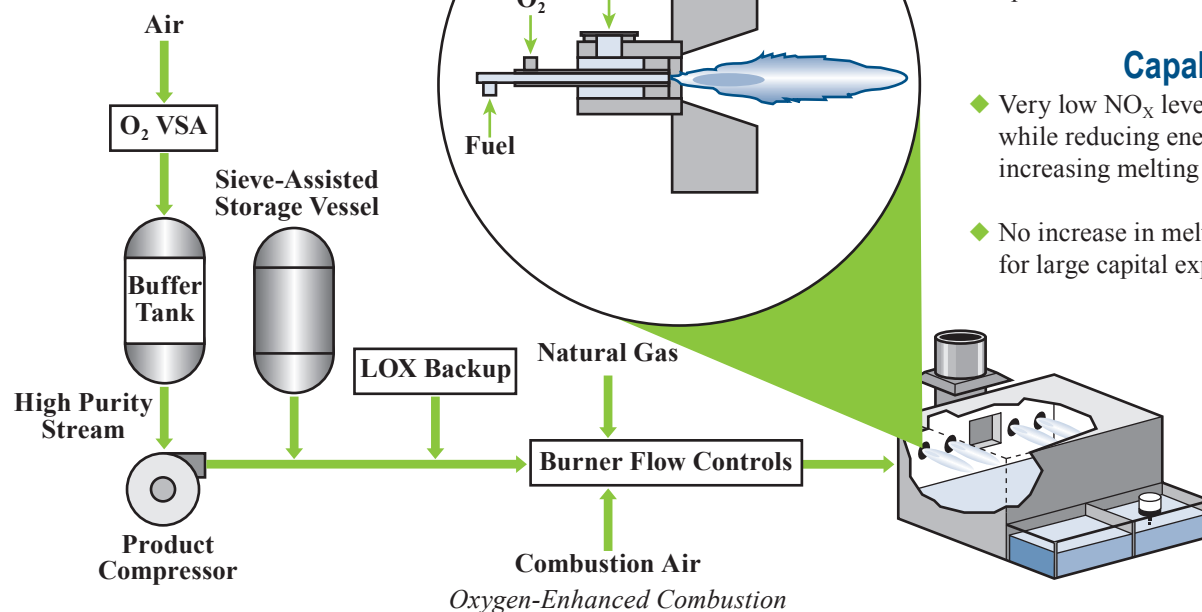
Using oxygen from storage reduces the overall oxygen consumption and costs by 33% compared to the previously installed burner.

Environmental Quality

Reduces NO_x emissions by 80%. Carbon monoxide is also significantly reduced. Both contaminants are well within stringent compliance levels.

Productivity

Increases production rate by 26%.



Overview

- ◆ Developed by Air Products & Chemicals, Inc.
- ◆ Demonstrated at Wabash Alloys in East Syracuse, NY
- ◆ Commercialized in 1999

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.025	0.0

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.0	0.0

Applications

- ◆ Can be retrofit to reverberatory furnaces commonly used to melt recycled aluminum
- ◆ Other metal melters for zinc, lead, copper, and nonferrous and ferrous metals
- ◆ Metal tolling and dross recovery operations

Capabilities

- ◆ Very low NO_x levels maintained while reducing energy use and increasing melting productivity.
- ◆ No increase in melting cost or need for large capital expenditures.

Recycling of Aluminum Dross/Saltcake Waste

IMPACTS

New Technology for Recovering Aluminum Dross/Saltcake Waste Saves Energy and Reduces Waste

The melting process used by the secondary aluminum industry when recycling aluminum creates a waste stream known as black dross/saltcake (dross). It is estimated that up to 1 million tons of dross is generated and landfilled annually in the United States. In the past, efforts to recover useful material from the dross have resulted in recovery of only a small portion of aluminum (about 3% to 10% of processed dross). The remaining 90% + of the dross, at best some 900,000 tons, is landfilled. Significant embodied energy could be saved from recovering three different components of the dross: aluminum, spent salt flux, and nonmetallic products (NMP).

With assistance from the NICE³ Program, Alumitech, Inc. undertook a successful 15-month plant construction and start-up project to commercialize a process to facilitate closed-loop recycling of dross through the manufacture of industrial ceramic products from recovered nonmetallic waste.

Starting with the dross material, Alumitech separates the dross into its basic components—aluminum metal, fluxing salts, and NMP. The aluminum metal and salt fluxes can be sold back to the secondary aluminum or other industries. In 2004, aluminum metal was recovered with an embodied energy savings of about 11 million Btu per ton of dross processed with this new system. A project goal was to commercialize a new process and to make NMP usable for a variety of product applications.

Benefits

Productivity

Alumitech process not only separates the aluminum and commercial oxides for reuse but also can recycle the remaining NMP into commercially salable products completely avoiding landfilling.

Use of Raw Materials/Feedstocks

Recovers materials for use as feedstocks in other process operations, thus conserving raw materials.

Waste Reduction

Products from NMP being developed will reduce landfill to zero for secondary aluminum operations.

Overview

- ◆ Developed by Alumitech, Inc.
- ◆ Commercialized in 1997
- ◆ 3 units operating in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
9.48	2.04

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.005	0.242	0.287	36.5

Applications

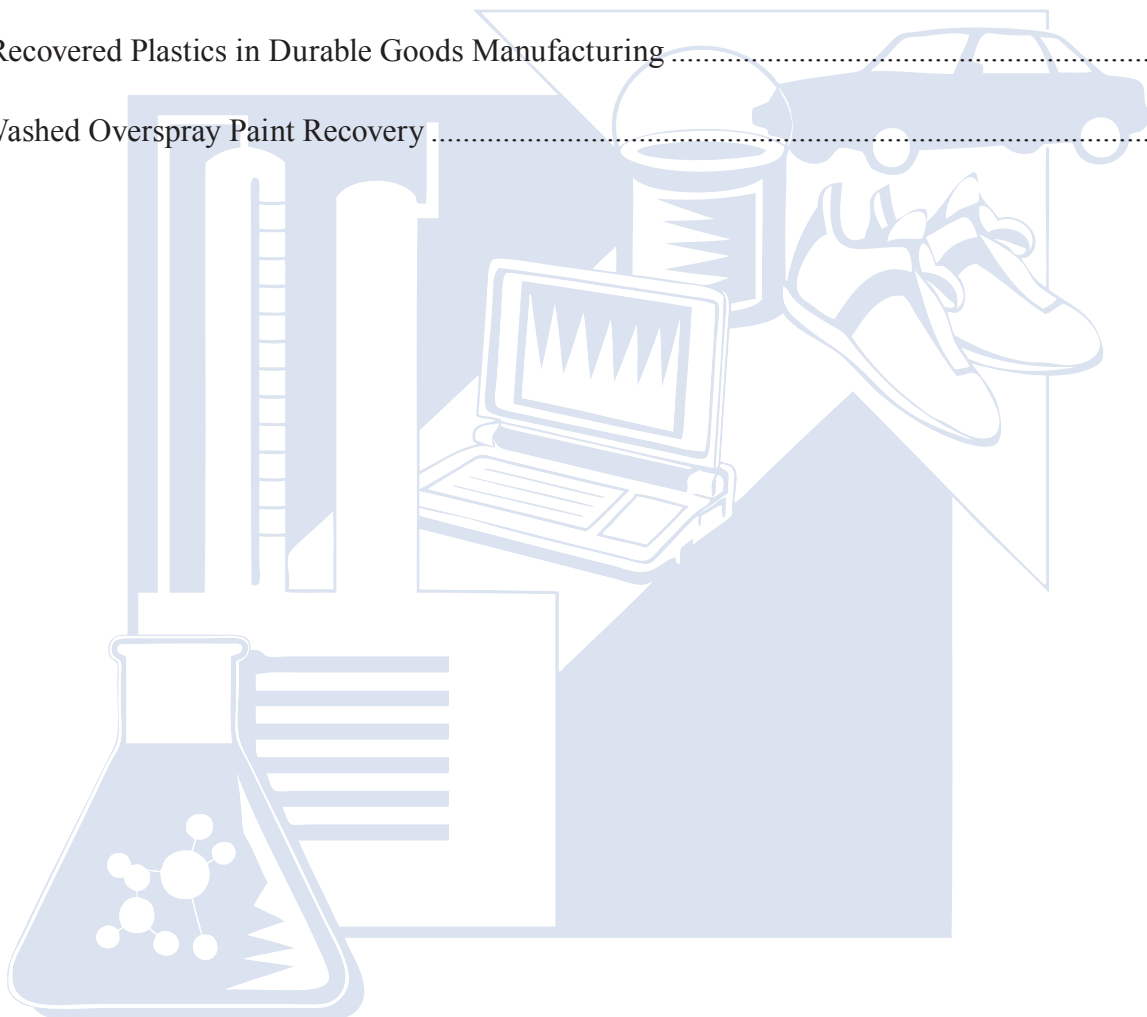
- ◆ Secondary aluminum process waste steams
- ◆ Steel-making slag products and ceramic fiber feedstock developed from waste material

Capabilities

Provides complete closed-loop recycling of secondary aluminum black dross/saltcake waste streams.

IMPACTS

◆ Aqueous Cleaner and CleanRinse™ Recycling System	22
◆ DryWash®	23
◆ Dual-Cure Photocatalyst	24
◆ Micell Dry-Cleaning Technology	25
◆ No-VOC Coating Products	26
◆ Powder Paint Coating System	27
◆ Pressure Swing Adsorption for Product Recovery	28
◆ Supercritical Purification of Compounds for Combinatorial Chemical Analysis	29
◆ Ultrasonic Tank Cleaning	30
◆ Use of Recovered Plastics in Durable Goods Manufacturing	31
◆ Water-Washed Overspray Paint Recovery	32



Aqueous Cleaner and CleanRinse™ Recycling System

IMPACTS

New Recycling System Improves Aqueous Cleaning System

Most traditional systems for pollution control focus on the end-of-pipe treatment and disposal of waste. The U.S. Environmental Protection Agency (EPA) has mandated a new emphasis on improved resource usage that focuses on source reduction. Many methods, including filtration, reverse osmosis, de-ionization, and distillation, could help meet this goal but often have high energy needs or produce additional waste streams.

With assistance from DOE's Inventions and Innovation Program, EcoShield Environmental Systems developed a simple mini-reactor system that chemically converts organic oily contaminants into surfactants and emulsifiers. This conversion increases the cleaning solution's ability to remove oil, grease, and dirt. The system regenerates the cleaning solution on site, creating less waste water and often decreasing the cleaning time required. The system has low energy needs and can be coupled with an energy-efficient bioreactor that will convert excess soap into biomass. The current applications of the technology have resulted in tremendous waste prevention and large cost savings.

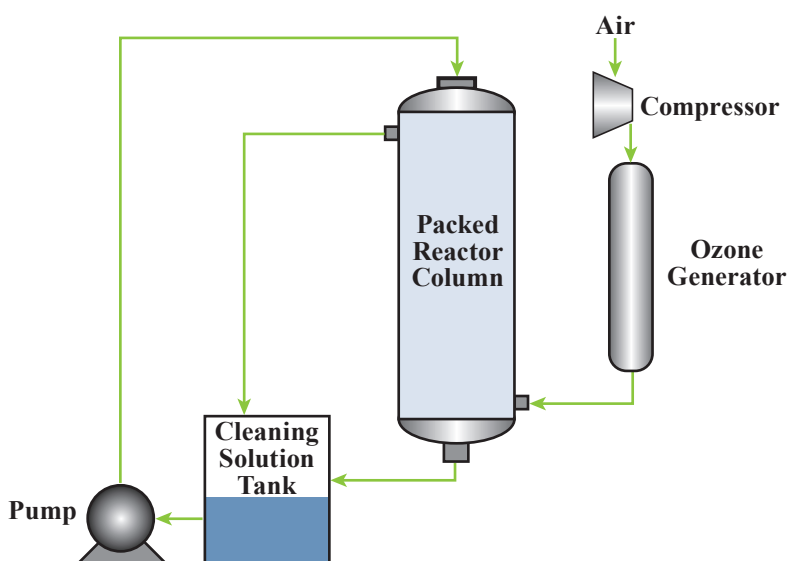
Benefits

Productivity

The system extends the life of the cleaning solution and rinse water, which reduces the costs associated with waste water disposal and chemical consumption. The system also has low operational costs (less than 5 cents per hour).

Waste Reduction

The technology reduces the chemicals typically consumed in the traditional cleaning process and extends the life of the cleaning solution. The system can be integrated with EPA's permanent pollution prevention plans.



EcoShield Aqueous Cleaner

Overview

- ◆ Developed by EcoShield Environmental Systems under an exclusive license from EcoShield Environmental Technologies Corporation
- ◆ Commercialized in 1997

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.119	0.015

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.002	0.235

Applications

Neutral to basic pH applications where aqueous waste streams containing organic contaminants are to be cleaned

Capabilities

- ◆ Converts excess soap to biomass using an optional companion bioreactor.
- ◆ Offers custom sizes and configurations for wash racks, cabinet washers, and automated lines.
- ◆ Is applicable for high-temperature installations.

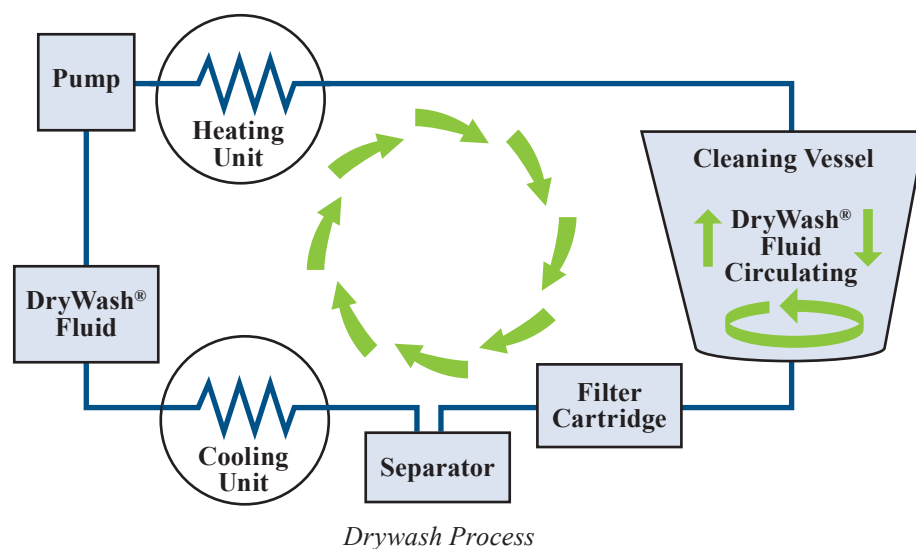
IMPACTS

A New Generation of Chemicals for Cleaning Applications

With ITP support, Raytheon Technologies, Inc. (formerly Hughes Environmental) and Los Alamos National Laboratory used defense-related expertise in supercritical fluids to develop DryWash, an entirely new CO₂-based system for dry cleaning fabrics. Current dry-cleaning practice uses perchlorethylene as the cleaning solvent to loosen and remove dirt from the fibers of clothing material. However, the dry-cleaning industry must eliminate its use of perchlorethylene because both the atmospheric emissions and the chemical itself have significant environmental impacts. Based on the desirable characteristics of CO₂ – it is inert, stable, non-corrosive, and non-flammable – the DryWash system introduces a new generation of technology to the dry cleaning industry.

DryWash uses liquid CO₂-based fluid (not generic CO₂) as the base solvent, but adds a new surfactant (dirt removing detergent additive), and then applies this new combination of cleaning liquids with a unique spraying device and agitation mechanism – all in a self-contained system. The DryWash process soaks the clothes in a liquid CO₂ filled tub at a pressure of 700 to 750 pounds per square inch and 54°F to 58°F. The load is agitated and at the end of the cycle, the dirt and oily residue drop out and CO₂ pressure is lowered, allowing for the efficient recycling of CO₂.

Global Technologies LLC began introducing the DryWash system in Europe in the fall of 1998 and started marketing in the United States in mid-1999. Commercial systems are now being sold by Alliance Laundry Systems LLC and SailStar USA.



Overview

- ◆ Developed by Raytheon Technologies, Inc. and commercialized by Global Technologies, LLC
- ◆ Commercialized in Europe in 1998 and the United States in 2000 with over 56 machines in operation in the United States

Energy Savings (Trillion Btu)

Cumulative through 2004	2004
0.031	0.008

Emissions Reductions (Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.001	0.001	0.155

Applications

Replaces conventional dry-cleaning systems that use perchlorethylene or petroleum-based solvents

Capabilities

- ◆ Uses an environmentally benign solvent (CO₂ based fluid) rather than hazardous solvents.
- ◆ Cleans equal to or better than conventional systems.
- ◆ Reduces cycle time by eliminating the energy-intensive drying step in the process.

Benefits

Profitability

Reduces cycle time by 50% and lowers operating costs.

Quality Improvement

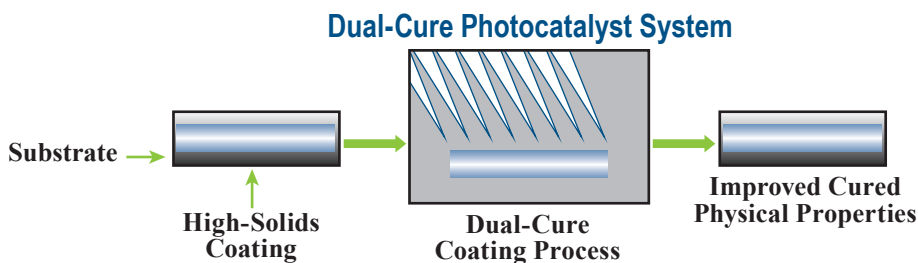
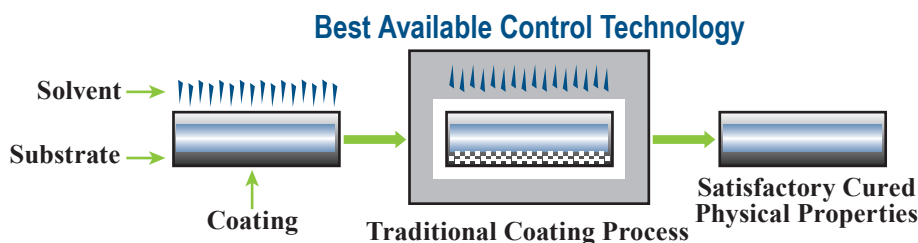
Decreases dirt redeposition and dye transfer and has better performance in oily, particulate soil and stain removal. Reduces shrinkage and has better color retention.

Low VOC Coating Process Reduces Emissions

As part of a constant search for new technologies that protect our environment and use carbon-based resources most efficiently, 3M with support from ITP, developed a new generation of paints, coatings, adhesives, and sealants incorporating new binding systems for civilian and military applications. Traditional volatile organic compound (VOC)-based coatings release undesirable organic chemical vapors into the atmosphere during the drying or curing phase of the coating application. The new and replacement products do not sacrifice performance, appearance, or ease of application, and demonstrate superior consistency and reliability.

The basis of the dual-cure process is a novel photocatalyst system that allows light-activated, simultaneous polymerization of two monomers to produce a material consisting of two independent but interpenetrating polymer networks (IPNs). The properties of these IPNs are generally superior to either separate component.

Because of the variety of monomers that can be used, the dual-cure process allows greater flexibility in tailoring the final properties of the cured coatings for specific applications. The VOC emission levels from this process are substantially below those obtained using conventional coating technologies, and cure times are shorter.



Coating Technologies

Overview

- ◆ Developed by the 3M Company
- ◆ Commercialized in 1993
- ◆ 5.52 million pounds of coating used in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
3.71	0.491

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.021	0.062	8.17

Applications

Process used as a coating and binder system for a variety of coated products

Capabilities

- ◆ Uses photocatalysts (activated by exposure to light) to simultaneously polymerize two monomers to produce a novel coating without VOC-emitting solvents.
- ◆ Demonstrated cure of the coatings at temperatures as low as 60°F.

Benefits

Cost Savings

Cost is comparable to that of current coatings. Requires no solvent.

Productivity

Reduces application time and requires no solvent disposal or heat for evaporative drying. 3M reports a 4% to 6% increase in yield and a 20% to 30% increase in productivity.

Product Quality

Has greater durability, tensile strength, and flexibility.

IMPACTS

New Cleaning Method Eliminates Use of Harmful Chemicals while Saving Energy

Micell Technologies developed a new dry cleaning technology using patents and know-how that is based on ITP sponsored research on CO₂ surfactant technology performed by the Pacific Northwest National Laboratories. The Micell CO₂ dry cleaning technology is called the Micare™ system. Micell Technologies is the parent company of Hangers Cleaners, who offers franchises incorporating the Micare dry cleaning technology. Currently, there are over 75 Hangers Cleaners locations across the country.

The heart of the Micare system is the specially designed MICO₂ machine with a 60-pound capacity and able to hold liquid CO₂. Garments to be cleaned are placed inside a large rotating basket in the MICO₂ machine and the door is closed, sealing the system. Carbon dioxide is added from the storage tank along with the Micare detergent package. This patented detergent system enhances the cleaning ability of the liquid CO₂ allowing it to remove dirt from the garments. After the cleaning cycle, the machine pulls the solution of liquid CO₂ and cleaning detergents away from the clothes, and then cleans and recycles the CO₂. Most (98%) of the CO₂ is recycled, while a small amount of CO₂ gas is then vented to the atmosphere. The cleaned garments are then removed from the wash tank after a cycle time of 35-45 minutes.

Benefits

Energy Savings

Eliminates the energy-intensive drying cycle used by conventional dry-cleaning systems.

Productivity

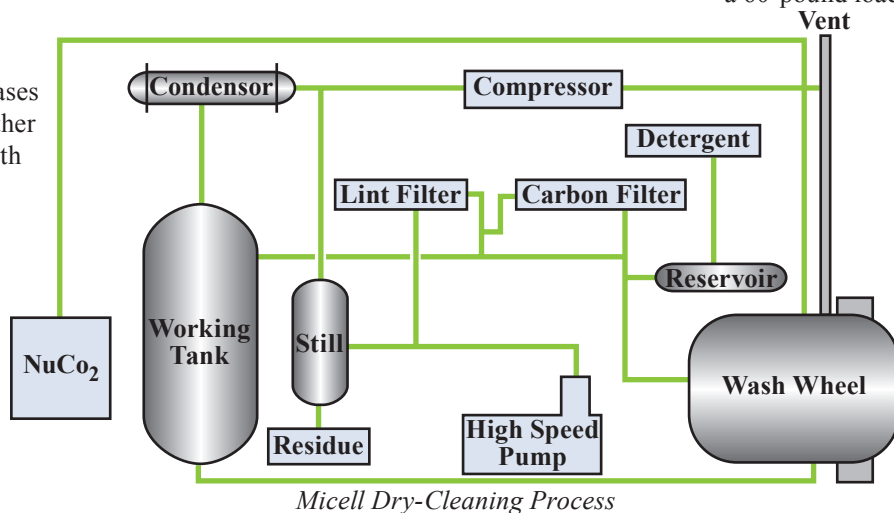
Reduces operating time and costs less to operate than the conventional perc systems.

Quality

Cleans effectively with no unpleasant odors, treats garments gently, and eliminates the chance of heat-related damage or setting of stains, as there is no drying cycle.

Waste Reduction

Eliminates harmful releases of perchlorethylene or other petroleum solvents to both the air and groundwater.



Overview

- ◆ Commercialized in 1999 by Micell Technologies
- ◆ In 2004, there were 29 Micell machines serving 75 Hangers Cleaners stores throughout the United States.

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.021	0.004

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.001	0.001	0.080

Applications

Replaces perchlorethylene or petroleum-based solvents used by conventional dry-cleaning systems

Capabilities

- ◆ Cleans equal to or better than conventional systems.
- ◆ Is similar to conventional front-load, mechanical action machines and features gentle wash and extract cycles.
- ◆ Requires only 35 to 45 minutes to clean a 60-pound load.

New Water-Based Coating Products Reduce Drying Time and Environmental Impacts

At present, a major concern of the coatings industry is the emission of volatile organic compounds (VOCs), which react with sunlight to create photochemical ozone or smog. VOC-containing solvents used in conventional liquid coatings evaporate during application, curing, and during clean-up operations. With help from a DOE NICE³ grant, Sierra Performance Coatings has developed new waterborne coatings that reduce or eliminate VOC emissions during formulation and application. The production of these new coatings requires lower processing temperatures, which reduces their energy impact. The coatings' quick-drying characteristics save further energy by avoiding heating and ventilation in the drying process.

Waterborne non-VOC coatings substitute water for a portion of the solvent used as the resin retainer in typical organic coating formulations. These new coatings can be applied to many surfaces including metal products. The quick-drying formulation reduces energy needs for drying and eliminates installation problems associated with harmful vapors. Many of these new products dry far more quickly than other products so multiple coats can be applied in one day rather than two or three. This dramatically cuts labor costs and returns the facility to use much sooner. Similarly, the corrosion resistance of Sierra's coatings are superior to any solvent-based coatings on the market.

Benefits

Energy Savings

Reduces or eliminates the energy for drying in-line production processes.

Emissions Reductions

Reduces environmental impact and increases compliance with regulations and environmental requirements.

Productivity

Speeds drying and uses simple water clean-up, thereby reducing downtime between coats and at the end of jobs. Reduced emissions also reduce ventilation equipment and labor.

Safety

Eliminates skin irritation from solvent contact and reduces exposure to harmful vapors, the need for ventilation, and the risk of fire from organic vapors, resulting in safer installation.

Overview

- ◆ Developed by Sierra Performance Coatings and being marketed by RPM International, Inc.
- ◆ Commercialized in 1998
- ◆ 478,950 gallons produced and applied through 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.004	0.001

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.0	0.011

Applications

No-VOC solvents can be found as components of exterior opaque stains, exterior and interior semitransparent stains, waterproofing sealers, clear wood finishes, varnishes, and sanding sealers

Capabilities

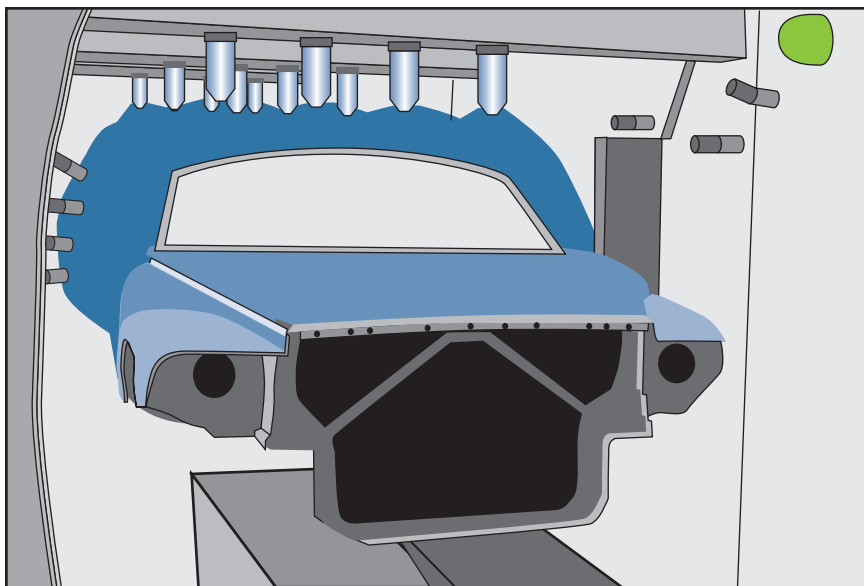
- ◆ Provides equal protection and material covering characteristics such as longevity and toughness with improved drying times and easier installation.
- ◆ Allows for quicker installation with none of the noxious fume problems associated with standard products.
- ◆ Reduces drying time and environmental impacts.

IMPACTS

Full-Body Powder Antichip Process Reduces Waste Emissions

Chipping paint is a major cause of customer dissatisfaction with United States-produced automobiles. The current standard for applying antichip primer to vehicles is a solvent-borne paint spray system that has a transfer efficiency (ratio of paint solids deposited on the vehicle to total volume used) of about 50%. In addition to generating a paint sludge by-product that must be landfilled, the process emits volatile organic compounds (VOCs). Chrysler Corporation developed and demonstrated, using a NICE³ grant, an innovative, new powder antichip process that contains no solvents and, considering recycling, has an effective transfer efficiency exceeding 99%. The new system virtually eliminates VOC emissions and paint sludge generation, eliminating the costs to transport and dispose of sludge.

Energy requirements for the powder process are much lower than for solvent-based processes. Though process air at 70°F is required for the application of either coating, in the new process a much smaller quantity of air needs to be heated, and the air from the powder booth can be recycled and reused directly because it contains no solvents. The energy that had been required to incinerate VOCs from the conventional process is conserved.



New Powder Antichip Primer Process

Overview

- ◆ Developed by the Chrysler Corporation
- ◆ Commercialized in 1996

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
5.10	0.603

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.004	0.071	9.63

Applications

Antichip primer application for automobiles

Capabilities

- ◆ Has transfer efficiency exceeding 90%.
- ◆ Has greatly reduced air-heating requirements.

Benefits

Energy Savings

Reduced air requirements and ability to recycle process air leads to greatly reduced air-heating requirements. Also eliminates energy requirements for incinerating VOCs.

Quality

Process gives better finish with reduced risk of delamination and chipping.

Use of Raw Materials

Conserves raw materials used to manufacture virgin coatings.

Waste Reduction

Contains no solvents, thereby reducing potential VOC emissions. Higher transfer efficiency reduces overspray, virtually eliminating solid waste generation.

Pressure Swing Adsorption for Product Recovery

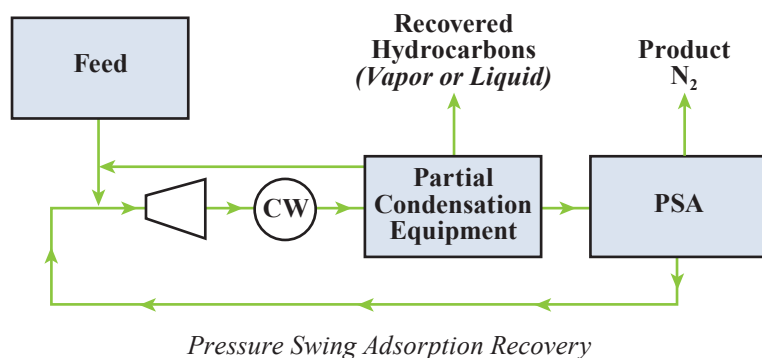
IMPACTS

Highly Selective Pressure Swing Adsorption Technology Recovers Valuable Components from Waste Streams

Many polyolefin plant designs use a polymer degassing step to remove unreacted monomer, solvents, and additives from the product polymer fluff before it is processed in downstream palletizing operations. When nitrogen is used as the stripping gas, the operation produces a low-pressure gas stream that typically contains nitrogen and valued hydrocarbons that can be recovered and recycled to the plant. If the gas is not processed for recovery, it is typically flared. The flaring step results in volatile organic compounds, NO_x, and CO₂ emissions. Flaring can also be costly, roughly equal to the value of the purchased nitrogen.

With assistance from DOE's Industrial Technologies Program, Air Products and Chemicals has developed a single unit operation to recover these gases. Pressure swing adsorption (PSA) is combined with partial condensation to essentially recover 100% of the hydrocarbons from the vent gas. In addition, QSA produces a high purity N₂ stream, with nearly 100% recovery of nitrogen. The recovered nitrogen can be recycled to the stripping operation or used elsewhere in the facility. Air Products' high recovery system eliminates waste streams and therefore emissions.

In this new process, the vapor stream from the partial condensation section flows into a PSA unit. Within the PSA, specially selected adsorbent materials extract hydrocarbons, thereby refining the nitrogen to a high purity with minimal pressure drop. Over time the adsorbent material in the bed becomes saturated and must be regenerated. Lowering the pressure in the saturated bed desorbs the hydrocarbon components from the adsorbent material in the PSA. The hydrocarbons are released and recovered in a low-pressure tail gas, which is recycled back to the compressor suction so the hydrocarbons are not lost. This technology provides a significant opportunity for energy and cost savings and reduced waste.



Overview

- ◆ Developed by Air Products and Chemicals
- ◆ Commercialized in 2003
- ◆ Installed in two locations in Texas

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.104	0.081

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.01	1.29

Applications

Both chemical and refining industries, including polyethylene and polypropylene production processes that use N₂ for degassing the polymer fluff and for treating refinery off-gas streams. This process could be adapted to recover valuable products from other waste streams throughout the industry.

Capabilities

- ◆ Recovers hydrogen, nitrogen, and hydrocarbons for reuse.
- ◆ Is flexible enough to operate using an external refrigeration source.

Benefits

Pollution Reduction

Exit streams from certain processes can be collected and separated for reuse, eliminating the emissions and need for disposal. Disposal typically involves flaring of the waste streams; therefore, this new process can save energy and costs by eliminating flaring.

Profitability and Productivity

Operating and emission costs are reduced by eliminating flaring, and productivity is increased by reusing products in the feed streams.

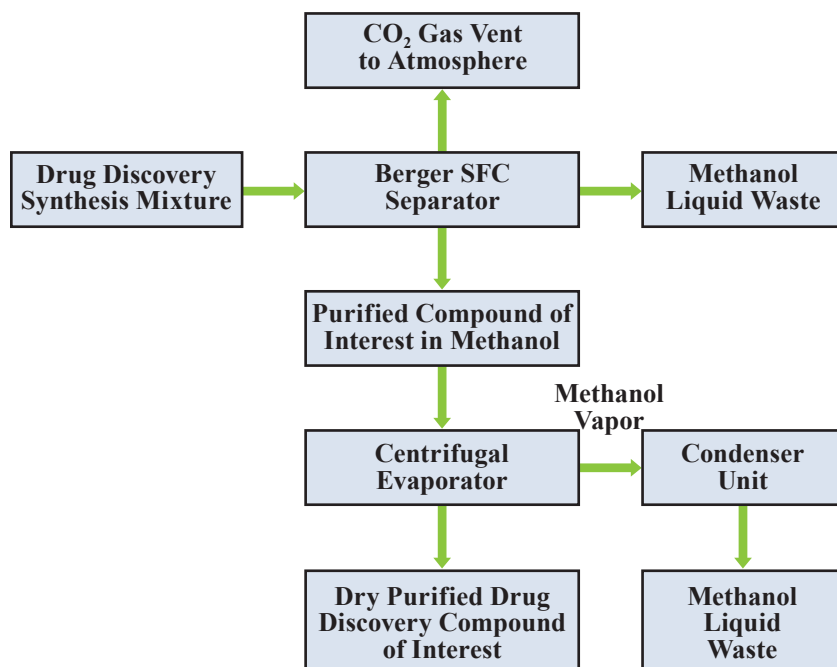
Supercritical Purification of Compounds for Combinatorial Chemical Analysis

IMPACTS

Innovative Purification Method Reduces Energy Use and Chemical Waste

With the support of a NICE³ grant, Berger Instruments, Inc., developed and demonstrated an innovative approach to combinatorial chemistry for the drug discovery industry called supercritical fluid chromatography (SFC). Conventional liquid chromatography (LC) systems are capable of purifying only 5 to 10 compounds per day. In addition, because of the wide variation in the number of complex chemical compounds that need to be tested, the LC process requires several manual operations, two to three trial runs, and up to 48 hours to remove organic/aqueous waste and water from the purified products. This time-consuming work poses a bottleneck for the pharmaceutical industry, which depends on high levels of throughput and purity.

Using the new SFC process, samples can be purified and dried 20 to 100 times faster than by conventional LC systems. SFC, a packed column analysis technique similar to LC, uses compressed gases such as CO₂ rather than liquid solvents as the primary component of the mobile phase. The high diffusivity and low viscosity of CO₂ results in greater speed and resolution than possible with LC. Additionally, the SFC technology provides a solute purity of 95% or greater, very rapid fraction collection with full automation, and no need for manual intervention. This new process also significantly reduces energy consumption and liquid-solvent waste generation.



Supercritical Fluid Purification System

Overview

- ◆ Developed by Berger Instruments, Inc.
- ◆ Commercialized in 2000
- ◆ 72 units operating in the United States in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
1.21	0.466

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.002	0.101	0.075	9.15

Applications

Process science and engineering technology for the pharmaceutical, chemical, and drug discovery industries

Capabilities

- ◆ Processes samples at higher speed with high purity.
- ◆ Approaches full automation without the need for manual intervention.

Benefits

Energy Savings

Uses 2% of the energy required by conventional LC technology.

Productivity

Processes samples 20 to 100 times faster while producing a purity of 95% or greater.

Waste Reduction

Reduces liquid chemical waste by 95% for each processed compound.

Ultrasonic Tank Cleaning Now a Viable Alternative to Solvent Cleaning

Although ultrasonic cleaning has long been the standard for small-scale cleaning applications, its technical limitations have precluded its use in larger applications. Chemical and pharmaceutical companies, for example, typically use volatile organic compound (VOC)-emitting solvents to clean their storage tanks in a process that is both labor- and energy-intensive. A new ultrasonic tubular resonator, developed by TELSONIC Ultrasonics and demonstrated using a NICE³ grant at DuPont-Merck Pharmaceutical Company, overcomes these limitations and has cleaned tanks with capacities of up to 2,300 gallons. The tube resonator produces an energy wave that propagates in all directions, rather than in a single direction like conventional ultrasonic systems, so a tank can be cleaned with less ultrasonic energy. The unit is small and can be placed into the tank through an opening in the top, eliminating the need for maintenance workers to enter the tank as required with conventional cleaning. Energy savings from the use of this technology are based on decreased cleaning energy use as well as the reduced use of solvents.

The resonator cleans tanks more quickly and thoroughly than solvents, uses less energy, and reduces labor and material costs. By eliminating the need to process spent solvents, ultrasonic cleaning also eliminates VOC emissions and hazardous wastes.

Benefits

Productivity

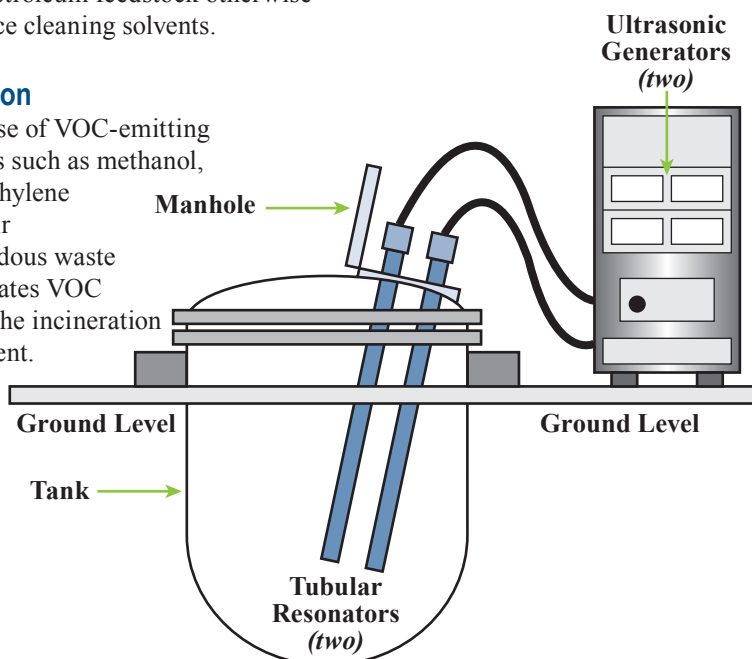
Reduces cleaning time from about 1 day to 1 hour.

Use of Raw Materials/Feedstocks

Conserves the petroleum feedstock otherwise needed to produce cleaning solvents.

Waste Reduction

Eliminates the use of VOC-emitting cleaning solvents such as methanol, ethanol, and methylene chloride and their associated hazardous waste streams. Eliminates VOC emissions from the incineration of the spent solvent.



Ultrasonic Tubular Resonator

Overview

- ◆ Demonstrated by DuPont-Merck Pharmaceutical Company
- ◆ Commercialized in the United States in 1994
- ◆ 20 units operating in the United States in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.040	0.005

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.001	0.071

Applications

- ◆ Cleaning residue from tanks used in chemical and pharmaceutical processing and remediation wells.
- ◆ Cleaning paint tanks such as those used in automotive painting operations

Capabilities

- ◆ Can clean tanks with capacities up to 2,300 gallons.
- ◆ Produces bubbles that are small enough to penetrate microscopic crevices, resulting in superior cleaning.
- ◆ Typical cleaning cycle times range from 1 to 3 hours compared with 8 to 24 hours for conventional cleaning methods.
- ◆ Saves the thermal energy used to convert the solvents from liquid to vapor.

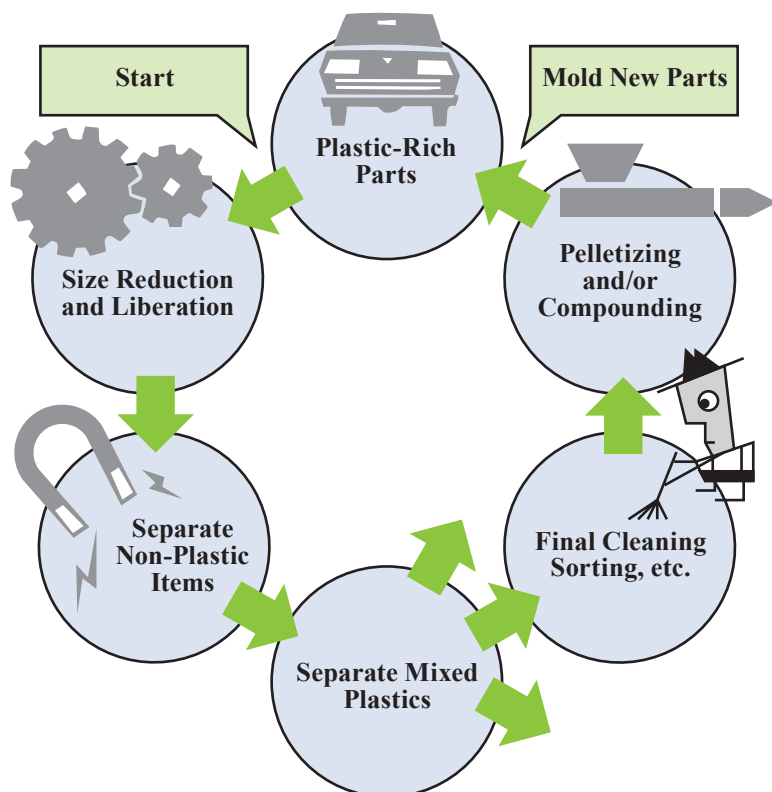
Use of Recovered Plastics in Durable Goods Manufacturing

IMPACTS

New Technology Helps Close the Recycling Loop for Plastics

An advanced mechanical recovery technology that can effectively recover plastic waste material has been developed by MBA Polymers, the American Plastics Council (APC) and plastic end-users, and demonstrated using a NICE³ grant. MBA's process is capable of running at rates over 5000 lb/hr and purifying as many as three different plastics from a single mixed stream. Conventional plastics cleaning and sorting processes (e.g., as used for bottle recycling) are inadequate to handle multi-component waste streams. The new demonstrated process incorporates several refined technologies that can separate metal and metallic coatings, rubber, glass, foam, and fabric as well as mixed plastics. These technologies include (1) enhanced size reduction throughput and particle size and shape control, (2) reduced product and side-stream contamination, (3) enhanced process control of separation systems for multi-material separations, and (4) advanced material separation capabilities.

The combination of these refined technologies produces an advanced plastic recycling system that is capable of effectively recovering previously unrecoverable streams of multi-component materials. The energy and related pollution savings from the MBA plastic recovery process come primarily from reducing the need to produce virgin plastics. Half of this energy is contained in the plastic itself as processed material and is lost if the scrap is not recovered or is incinerated. Using this recovered plastic instead of additional virgin plastic results in energy savings of 17,000 Btu per pound of raw material or more than 85% of the energy required for producing virgin plastics.



MBA Polymers' Recycle Loop

Overview

- ◆ Developed by MBA Polymers in 1995
- ◆ Commercialized in 1996
- ◆ Currently operating one plant in California
- ◆ Constructing plants in Austria and China

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.381	0.015

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.002	0.002	0.266

Applications

Recovery of plastic from complex manufacturing scrap and end-of-life durable goods including automobiles, appliances, electrical, and electronic equipment

Capabilities

- ◆ Separates as many as three different plastics at one time in a mixed waste stream.
- ◆ Segregates metal, metal coatings, rubber, glass, foam, and fabric from plastic waste.
- ◆ Recovers previously unrecoverable and discarded multi-component materials.

Benefits

Waste Reduction

Significantly reduces landfill requirements.

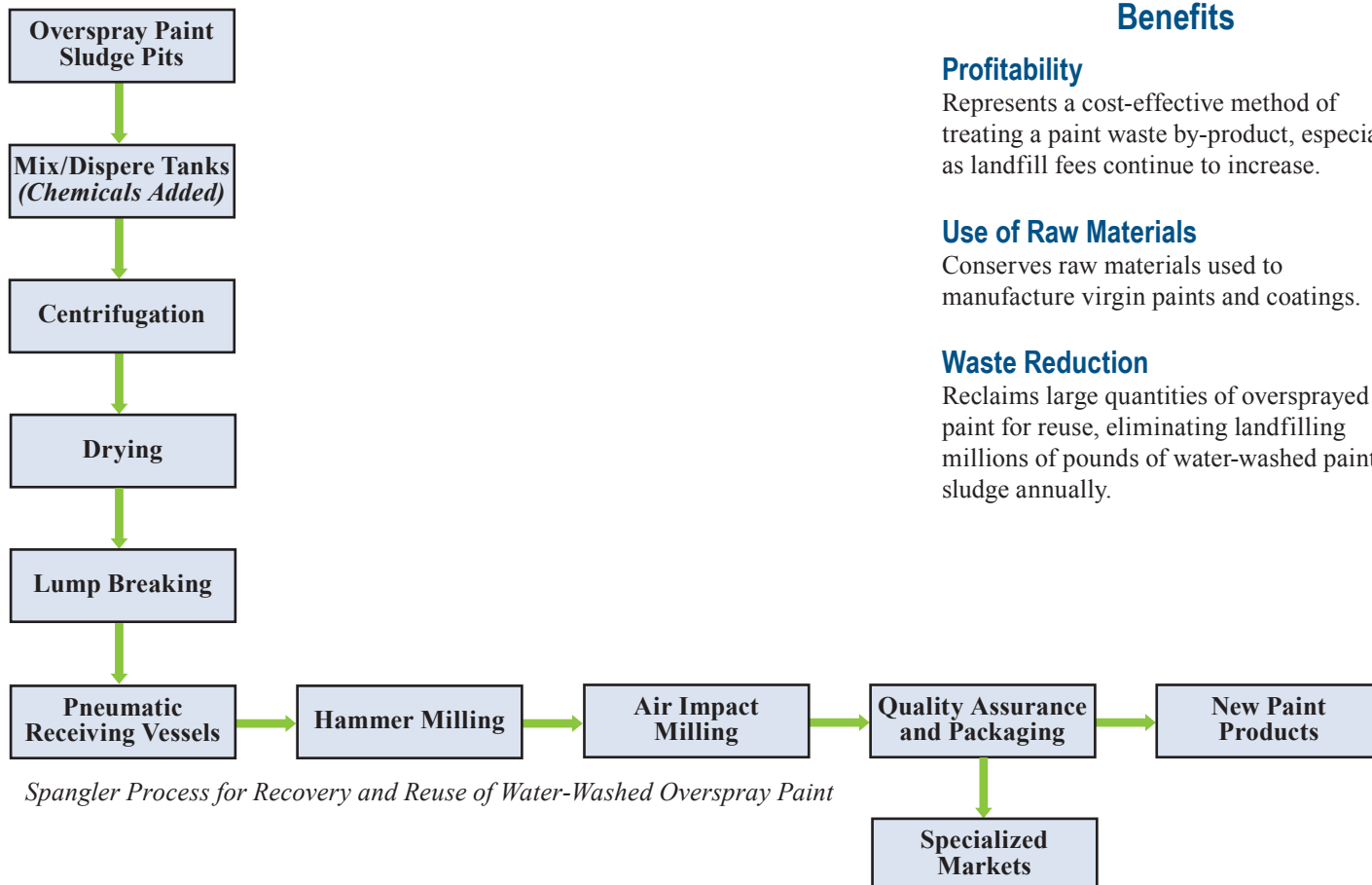
Waste Utilization

Recover previously discarded re-usable plastic materials and allows more cost-effective raw plastic materials for industry.

Process for Recovery and Reuse of Water-Washed Overspray Paint Reduces Waste

Industrial water-wash paint operations, such as those used to paint automobiles, have transfer efficiencies (the percentage of paint sprayed that actually adheres to the item being painted) ranging from 30% to 70%. As a result, approximately half of all paint purchased for these operations is essentially wasted. Landfilling has been the only feasible treatment option because no cost-effective recycling techniques exist to handle tacky, agglomerated paint sludge. Caterpillar, Inc. has developed and demonstrated the economically feasible Spangler process using a NICE³ grant. This process recovers oversprayed paint and then chemically and physically processes it. The reclaimed material is used in new, high-performance paints and coatings.

In the Spangler process, oversprayed particles suspended in water are captured and encapsulated by hydrophobic fumed silica particles. This encapsulation essentially detackifies the paint by-product without detrimentally altering its chemistry as a recyclable feedstock. After drying, the product—known as Precured Pigment Resin (PPR)—is pulverized and packaged to be returned to coatings suppliers for blending into new paint. Not only does PPR have no negative effect on the quality of the coating to which it is added, it may actually improve the anticorrosion properties of some paints. In addition to paint, PPR can be used in products such as electrodeposition coatings, interior/exterior maintenance coatings, and polyurethane primer. Caterpillar is currently refining the process and expects to use the product in-house and sell it commercially to other users.



Overview

- ◆ Developed by Caterpillar, Inc.
- ◆ Commercialized in 1995

Applications

Industrial water-wash paint operations such as automotive and construction equipment assembly plants

Capabilities

- ◆ Recovers and processes oversprayed paint for reuse in high-performance coatings.
- ◆ Detackifies oversprayed paint waste without destructively altering its composition.

Benefits

Profitability

Represents a cost-effective method of treating a paint waste by-product, especially as landfill fees continue to increase.

Use of Raw Materials

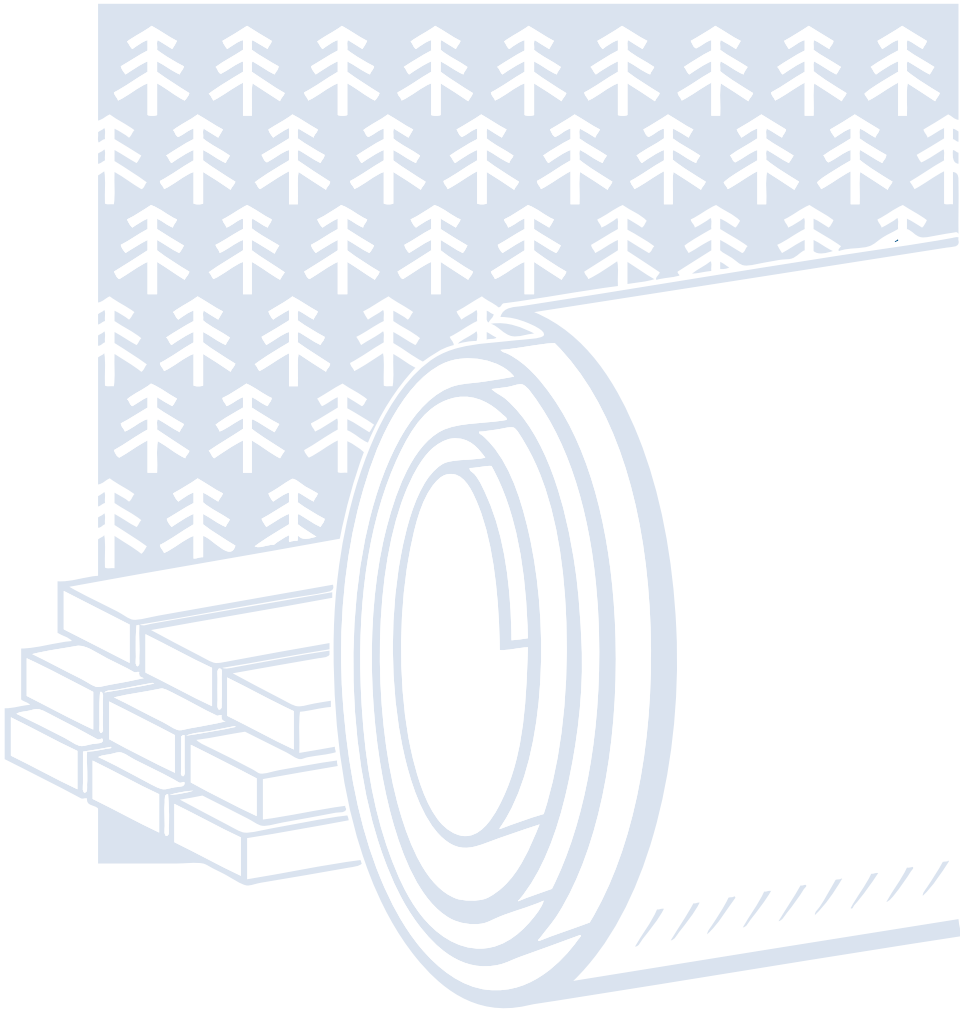
Conserves raw materials used to manufacture virgin paints and coatings.

Waste Reduction

Reclaims large quantities of oversprayed paint for reuse, eliminating landfilling millions of pounds of water-washed paint sludge annually.

IMPACTS

- ◆ Chemical for Increasing Wood Pulping Yield 34
- ◆ Continuous Digester Control Technology..... 35
- ◆ Detection and Control of Deposition on Pendant Tubes in Kraft Chemical Recovery Boilers 36
- ◆ Improved Composite Tubes for Kraft Recovery Boilers 37
- ◆ METHANE de-NOX® Reburn Process 38
- ◆ Optimizing Tissue Paper Manufacturing 39
- ◆ Pressurized Ozone/Ultrafiltration Membrane System 40
- ◆ Thermodyne™ Evaporator – A Molded Pulp Products Dryer.....41
- ◆ XTREME Cleaner™ – Removal of Light and Sticky Contaminants..... 42



Chemical for Increasing Wood Pulping Yield

IMPACTS

Novel Chemistry Improves Pulp Yield While Reducing Energy and Chemical Requirements

Unevenly processed wood chips in the pulp industry result in poor-quality pulp, often requiring reprocessing. ChemStone, Inc., in cooperation with the NICE³ Program, has demonstrated a cooking aid that reduces the amount of virgin wood feedstock needed to process wood chips. It also increases pulp yield and quality. The cooking aid is a molecule that remains soluble in the highly alkaline and hot environment for cooking pulp. The molecules help pulp-cooking liquors penetrate the chips, resulting in more uniform cooking. The rate of penetration into the chips enables the mill to produce a more uniform fiber in less time and with less energy. This chemistry eliminates overcooking the external chip to effectively cook the internal chip and eliminates the need to reprocess the uncooked portion. The reduction in cooking time translates into an energy savings of 125 thousand Btu per ton of wood chips processed.

The process greatly reduces sulfur-based emissions, such as hydrogen sulfide and methyl mercaptans. Approximately 1-million tons of emission gases are eliminated. Eleven United States mills are currently using this novel chemistry either full time or for part of their production. ChemStone is establishing a distribution network in South Africa, Europe, Indonesia, Canada, and Mexico.

Benefits

Pollution Prevention

Reduces sulfur-based emissions such as hydrogen sulfide and methyl mercaptans.

Product Quality

Produces better-quality pulp through less harsh cooking of the wood chips and less refining of the pulp, reducing rejects.

Use of Raw Materials/Feedstocks

Reduces consumption of raw wood for required production. Uses less bleaching chemicals to reach the required brightness.

Overview

- ◆ Developed by ChemStone, Inc.
- ◆ 11 pulp mills currently using the technology

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
8.08	1.09

Emissions Reductions

(Thousand Tons, 2004)

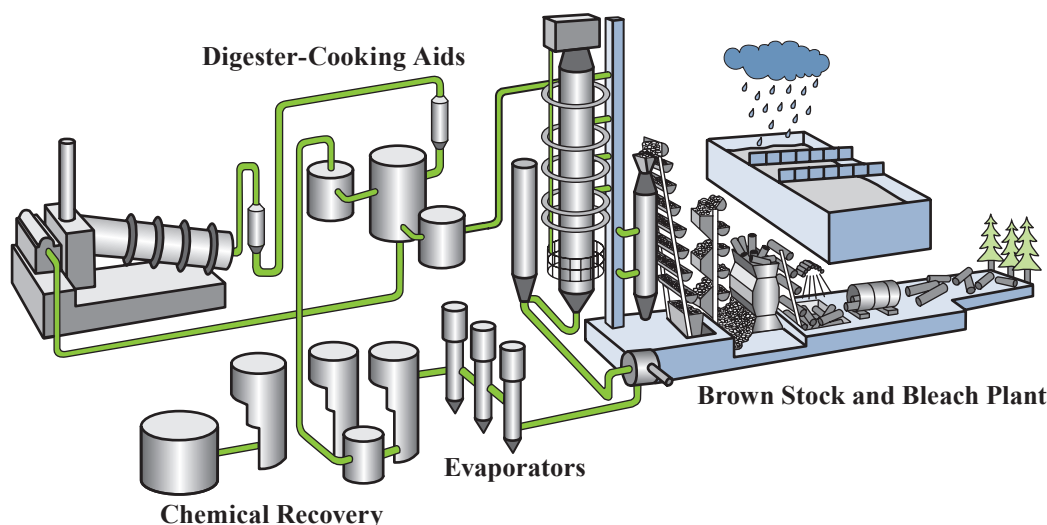
Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.128	17.3

Applications

All pulping processes

Capabilities

- ◆ Results in 2% to 5% increase in yield per ton of wood.
- ◆ Rejected pulp is reduced by 2% to 50%.
- ◆ Reduces the amount of fiber required for paper quality.



ChemStone Programs for Mill Optimization

Continuous Digester Control Technology

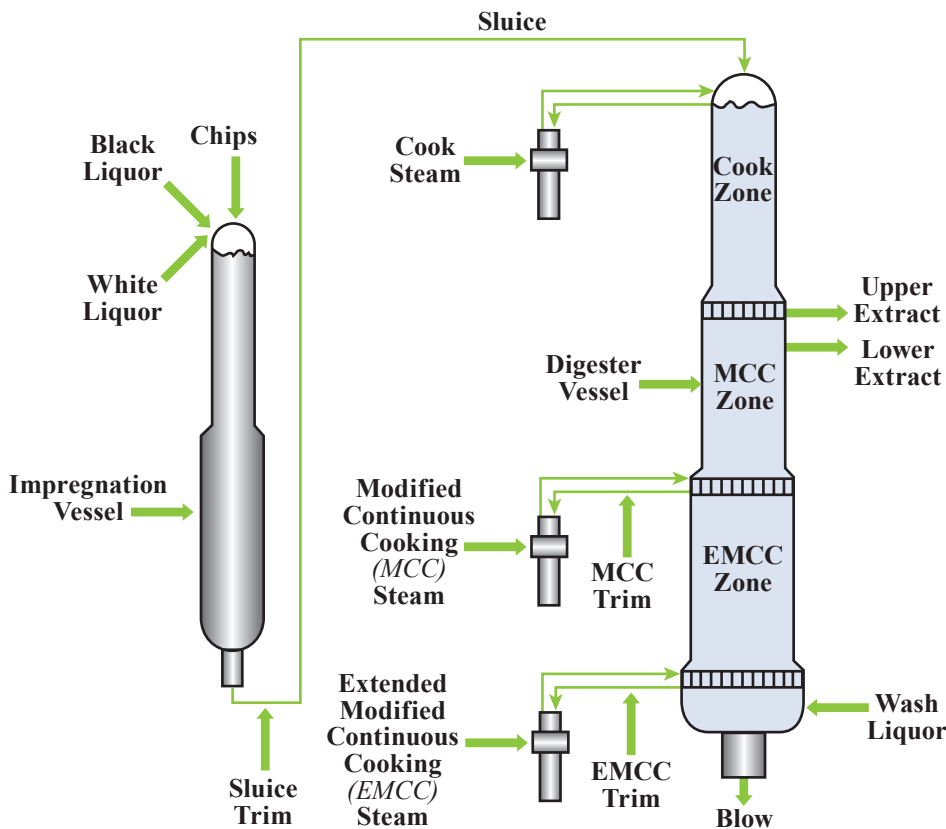
IMPACTS

Pulp Process Model Identifies Improvements that Save Energy and Improve Productivity

The pulp digester is known as the bottleneck unit in the pulp mill flow sheet because it can require 5 to 50% of typical on-line operation time, making this component of the pulping process very capital intensive. Improving digester performance can significantly reduce production losses, operating costs, and negative environmental effects while increasing paper quantity and quality. Using a computer-based model and control system for continuous digesters could regulate the pulping process, thereby minimizing mill downtime caused by digester problems and fostering continuous operation and pulp production.

Previous work conducted at the University of Delaware (UD) indicated that fundamental computer models could manage the internal conditions within the digester. The UD resolved the major challenge to designing such a model by developing a fundamental digester model that manages production rate changes and grade swings between hardwood and softwood feedstocks.

The digester's fundamental process model integrates physical and chemical properties as system "states" (i.e., points in the digester process) to track grade transitions. This model allows appropriate material, energy balance, and diffusion simulations to be calculated as various-origin chips pass through the digester. The observation and tracking of these data help identify process improvements. The model's first commercial application in a Texas mill allowed the temperature to be reduced in part of the pulping process, thereby saving 1% of the process energy.



Dual Vessel EMCC Continuous Digester

Overview

- ◆ Developed at the University of Delaware
- ◆ Commercialized in 2003
- ◆ Being marketed by IETEK

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
8.00	4.00

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.468	63.5

Applications

All types of pulp digesters and provides the basis for developing more model-based methods of soft sensing, diagnostics, and control

Capabilities

- ◆ Uses a computer model to evaluate the pulping process.
- ◆ Provides operational data through the model to identify process improvements.

Benefits

Environmental Impact

Minimizes the amount of chemicals used.

Productivity

Improves operator control, thus raising productivity and process reliability. Also improves system operability through rate and grade transitions.

Product Quality

Reduces pulp and paper quality variations.

Detection and Control of Deposition on Pendant Tubes in Kraft Chemical Recovery Boilers

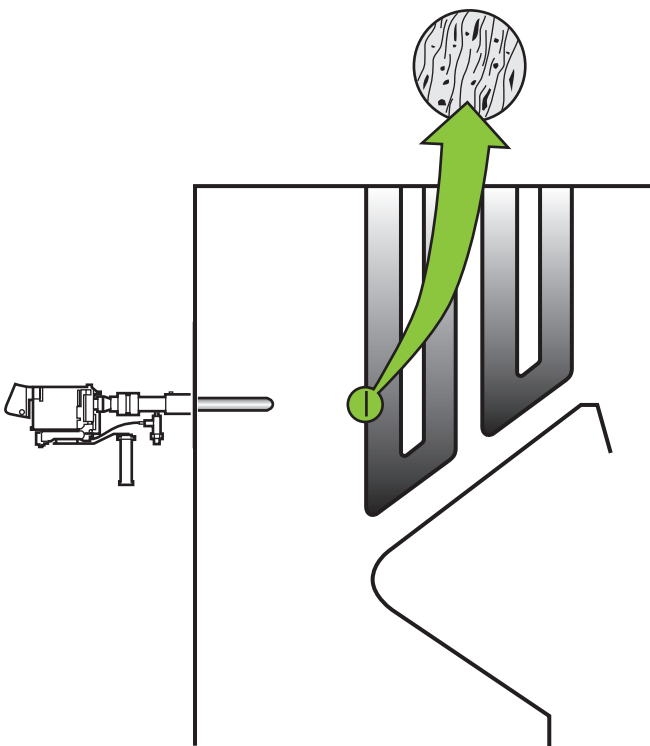
IMPACTS

Advanced Imaging System Improves Boiler Efficiency, Reduces Sootblowing Costs, and Improves Operational Safety

The kraft chemical recovery boilers used for pulp processing are large and expensive and can be the limiting factor for mill capacity. Improvements in boiler efficiency with better control of deposits on heat transfer surfaces (e.g. pendant tubes) and reductions in boiler downtime (due to pluggage or slag impact) can improve boiler capacity and reduce operating costs.

With assistance from DOE's Inventions and Innovation Program, Enertech, Inc., has developed a hand-held infrared inspection system. Using the inspection system technology, they have also established the feasibility of and are developing a continuous integrated monitoring sootblower control system to detect and control buildup of deposits. The early detection of deposits can extend the intervals between boiler shutdowns. The resulting improved boiler operation and reduced maintenance provide energy savings and productivity improvements to the pulp processing industry.

The hand-held inspection system has demonstrated reductions in sootblower steam use of up to 20%. This steam improvement is achieved because the frequency of sootblower operation is reduced, sootblowers can be repositioned based on data obtained from the inspection, and sootblower malfunction can be detected. Reduced pluggage and deposition in the boiler have also led to improved heat transfer rates. The integrated observation camera and sootblower control system (under development) are expected to reduce sootblower steam usage by 30-35% and improve heat transfer efficiency by 20%.



Hand-held Inspection System on a Kraft Recovery Boiler

Overview

- ◆ Developed by Enertech, Inc.
- ◆ Commercialized a hand-held device in 2002
- ◆ 44 units in use in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.660	0.484

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.004	0.281	0.075	10.5

Applications

Kraft recovery boilers in the pulp and paper industry and in the coal, cement, steel, and glass manufacturing industries

Capabilities

- ◆ Produces clear images and videos of boiler interiors despite highly particle-laden environments.
- ◆ Produces images at distances up to 100 feet, enabling inspection anywhere in the combustion chamber including the convection pass and economizer.

Benefits

Productivity

The hand-held inspection system reduces boiler downtime through early detection of defective fixtures (tube leaks or damaged sootblower). Without shutting down the boiler, the system also detects slag formation at an early stage, preventing impact damage and enabling cleaning before deposits harden.

Safety

The impact of sizable slag deposits on boiler internals can lead to severe damage and potential injury. The hand-held inspection system has enabled early detection and elimination of such deposits.

DOE Industrial Technologies Program

Improved Composite Tubes for Kraft Recovery Boilers

IMPACTS

New Alloys Improve Performance and Safety

Black liquor recovery boilers are critical components of kraft pulp and paper mills. These boilers burn organic waste to generate steam and electric power for the mill and allow the sodium hydroxide and sodium sulfide used in the pulping process to be recovered. The boilers are constructed with floors and walls of tube panels, and these tubes circulate pressurized water to permit generation of steam. Originally, carbon steel tubes were used for these tube panels, but severe corrosion thinning and occasional tube failure led boiler manufacturers to search for materials that could better survive in the recovery boiler environment.

As a result of this search, new weld overlay and co-extruded tubing alloys were developed and are now being used in United States kraft recovery boilers and foreign installations. These materials are currently produced by Welding Services Inc., Sandvik Materials Technology, and Sumitomo Metals for application in recovery boilers. Boiler manufacturers are using the technology in designing and fabricating new and rebuilt kraft recovery boilers

A series of alloy studies, conducted by Oak Ridge National Laboratory, Pulp and Paper Research Institute of Canada, and the Institute of Pulp and Paper Science and Technology showed that Alloys 825 and 625 are more resistant than 304L stainless steel to cracking. Sandvik Materials Technology produces Sanicro 38 (modified 825) composite tubes for the world's largest manufacturers of black liquor recovery boilers. The boilers have been delivered to plants in the US, Australia, Belgium, Brazil, Canada, China, France, Finland, Sweden, Germany, Spain and Norway.

Benefits

Environmental

The change in operating conditions resulting from the improved materials will reduce gaseous emissions.

Productivity

Improved materials enable the use of black liquor with higher dry solids content, thus increasing the thermal efficiency. The improved materials decrease the number of shutdowns and improve the overall boiler efficiency and productivity.

Safety

In recovery boilers, tube leaks can result in serious explosions if the pressurized liquid contacts the molten salt on the floor and walls of the boiler. The use of improved materials significantly reduces the cracking of the floor and wall tubes, thus reducing the likelihood of a boiler tube leak.

Overview

- ◆ Currently produced by Welding Services Inc., Sandvik Materials Technology, and Sumitomo Metals for application in recovery boilers
- ◆ Commercialized in 1996 and installed in over 17 kraft recovery boilers in the United States

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.038	0.007

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.002	0.001	0.128

Applications

Being used in constructing new and rebuilt kraft recovery boiler floors

Capabilities

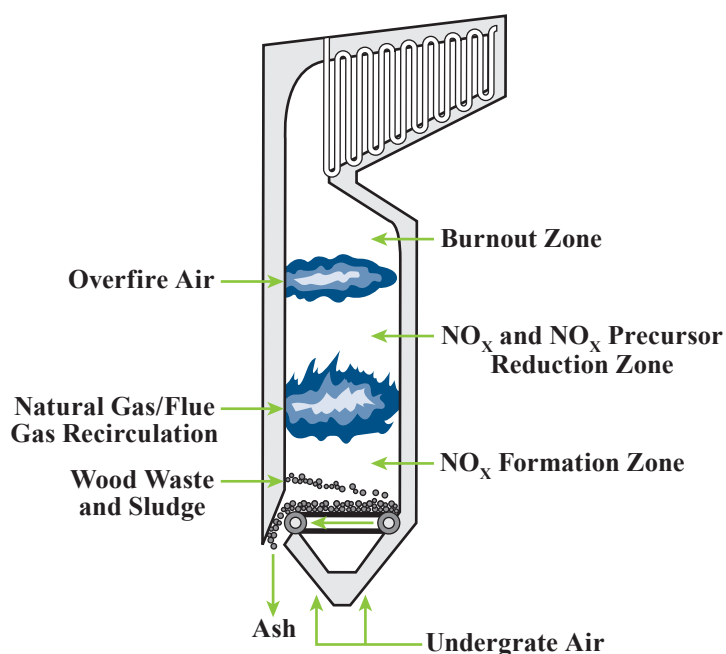
The new materials can operate in the aggressive environments that can cause stress corrosion cracking of 304L stainless steel.

METHANE de-NOX Reburn Process Uses Waste Wood for Biomass-Fired Stoker Boilers

The METHANE de-NOX process is a reburn technology using 5% to 25% natural gas heat input for improving combustion of solid waste fuels and for controlling emissions of NO_x and CO. The METHANE de-NOX process injects natural gas above the grate and uses flue gas recirculation to enhance mixing and create an oxygen-deficient atmosphere that retards NO_x formation. Overfire air is injected higher in the furnace to burn out the combustibles. The technology has been successfully demonstrated in commercial power plants using municipal solid waste and coal as fuel. In these demonstrations, the combustion systems operated more efficiently; required less maintenance; and reduced emissions of NO_x, CO, and VOCs.

With assistance from ITP, the Gas Technology Institute (formerly the Institute of Gas Technology) demonstrated the METHANE de-NOX reburn technology in the forest products industry. The project involved a field demonstration on a 300 million Btu/hr stoker-fired boiler fueled with waste wood and paper sludge at Boise Paper Solutions' paper mill in International Falls, MN. After the boiler was retrofitted, performance tests confirmed that the added heat released from natural gas combustion above the stoker grate stabilized the firing of solid fuel, permitted uniform heat release, reduced localized peak temperature, and permitted greater load flexibility including low load operation, thus improving combustion of difficult-to-burn waste fuels.

Commercial implementation of the technology provides the forest products industry with a means to use (rather than landfill) more waste wood solids and sludges, reduce natural gas consumption and NO_x emissions, and improve boiler thermal efficiency.



METHANE de-NOX Process

Overview

- ◆ Developed by the Gas Technology Institute
- ◆ Commercialized in 1998
- ◆ Two units operating at paper mills and 26 units on coal-fired cogeneration boilers

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
1.16	0.218

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.001	0.031	0.034	4.06

Applications

A wide range of wastewood and sludge-fired stoker boilers in the forest products industry and coal-fired boilers

Capabilities

- ◆ Improves grate combustion of difficult-to-burn fuel such as high-moisture-content waste wood.
- ◆ Substantially reduces NO_x emissions and natural gas input while increasing sludge firing rates and thermal efficiency.
- ◆ Provides a cost-effective means to use abundant waste wood solids and sludges for energy generation rather than land-filling them.

Benefits

Ease of Operation

Cleaner gas passes through the furnace with less fouling and unburned carbon and fly ash at the bottom.

Productivity

Sludge firing increases from 1.2 up to 5 tons/hour and boiler thermal efficiency increases by 1% to 2% resulting in greater steam production capacity.

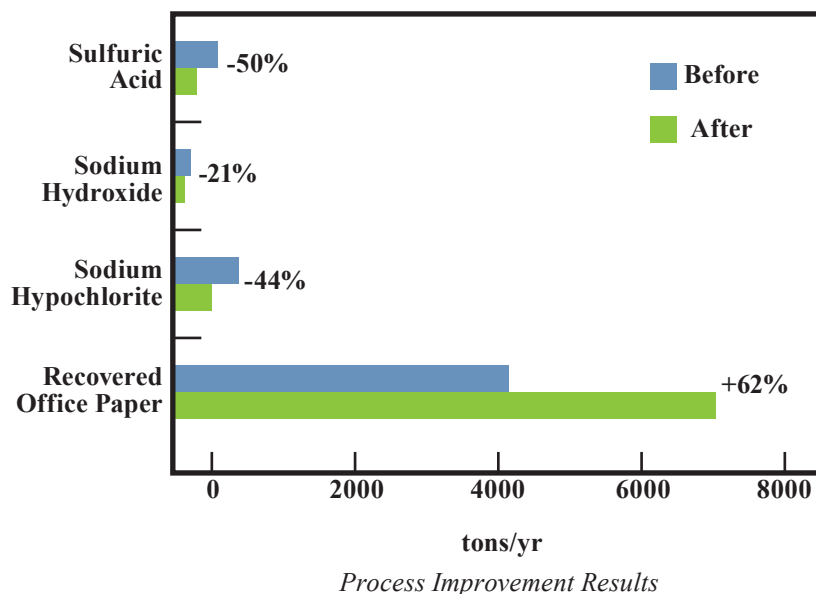
Optimizing Tissue Paper Manufacturing

IMPACTS

Optimizing Tissue Paper Manufacturing Increases Paper Recycling

Government standards and customer requests led Erving Paper Mills Inc. to modernize its de-inking process to increase the amount of recovered office paper used in producing paper napkins and tissue. De-inking is the process of removing inks, dirt, and other contaminants from the fibers used in making paper products. Waste paper is made into a slurry, and the contaminants are removed mechanically by size.

Using a NICE³ grant, Erving Paper Mills demonstrated changes to its process, which included de-ink equipment upgrades, on-line image analysis, alternative chemistry trials, and other energy-conservation projects. These improvements reduced energy and toxic chemical usage and increased the amount of recovered office paper in the feedstock. The improvements in de-inking equipment included system reconfiguration, new high-efficiency cleaners, a new high-efficiency flotation cell, and a new high-efficiency washer. These improvements resulted in higher efficiencies for removing dirt, better washing, improved clarification for process water, and lower bleaching requirements.



Overview

- ◆ Developed by Erving Paper Mills, Inc.
- ◆ System modifications began in late 1996

Applications

- ◆ Production of tissue and napkin products
- ◆ Pulp and paper mills

Capabilities

Increased use of recovered office papers- from 10.5% to 17% of total feedstock.

Benefits

Energy Savings

Lower pulping temperatures decrease fuel oil usage. Conservation projects resulted in reduced electrical energy.

Emissions Reductions

Lower pulping temperature and new continuous-belt washer decreases solvent usage, resulting in reduced emissions of volatile organic compounds.

Use of Raw Materials/Feedstocks

Increasing amount of recovered office paper decreases amount of direct-entry recycled fiber used. Changes to de-inking process decreases use of several controlled chemicals

Pressurized Ozone/Ultrafiltration Membrane System

IMPACTS

Novel Process Dramatically Reduces Energy Use, Improves Process Water Quality, and Reduces Effluent Discharge

With the support of a NICE³ grant, LINPAC, Inc., demonstrated a novel technology for closed-loop systems that uses pressurized ozone with dissolved air flotation and an ultrafiltration membrane in series. This system allows total dissolved solids in process water to be readily converted to total suspended solids for efficient removal. Contaminated mill process water thereby can be continually and cost effectively cleaned to the high-quality process water standards required for reuse in the mill. After passing through the new system, process water is far cleaner and of higher quality than water from other processes and requires far less energy for reheating than fresh water. The system reduces the production problems associated with buildup of total dissolved solids (TDS) in paper mill operations and provides operational benefits such as reduced energy needs and fewer chemicals and additives. The system also results in production and quality gains because of the higher-quality process water. Because the environmentally friendly system allows paper mills (and other water-intensive manufacturing mills) to operate in a closed loop, effluent discharge to rivers and waterways is eliminated or drastically reduced. This new system substantially reduces both effluent discharge and the need for fresh water.

Benefits

Environmental

Removes TDS in mill process water, thereby allowing mills to eliminate or reduce effluent discharge. Eliminates CO₂ discharges of up to 815 tons a year for a typical plant operation. Potentially reduces landfill waste by 50% and use of processing chemicals by \$5/ton of paper produced.

Productivity

Clean process water allows production gains of 5% to 15%. Saves energy costs due to heating and drying. Reduces chemical additive use. Potentially reduces downtime in mill process water treatment systems.

Overview

- ◆ Developed by LINPAC, Inc., and Cellulose Products and Services LLC
- ◆ Commercialized in 2004 and marketed by Cellulose Products and Services LLC
- ◆ Currently installed and operating in a LINPAC paper plant

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.315	0.315

Emissions Reductions

(Thousand Tons, 2004)

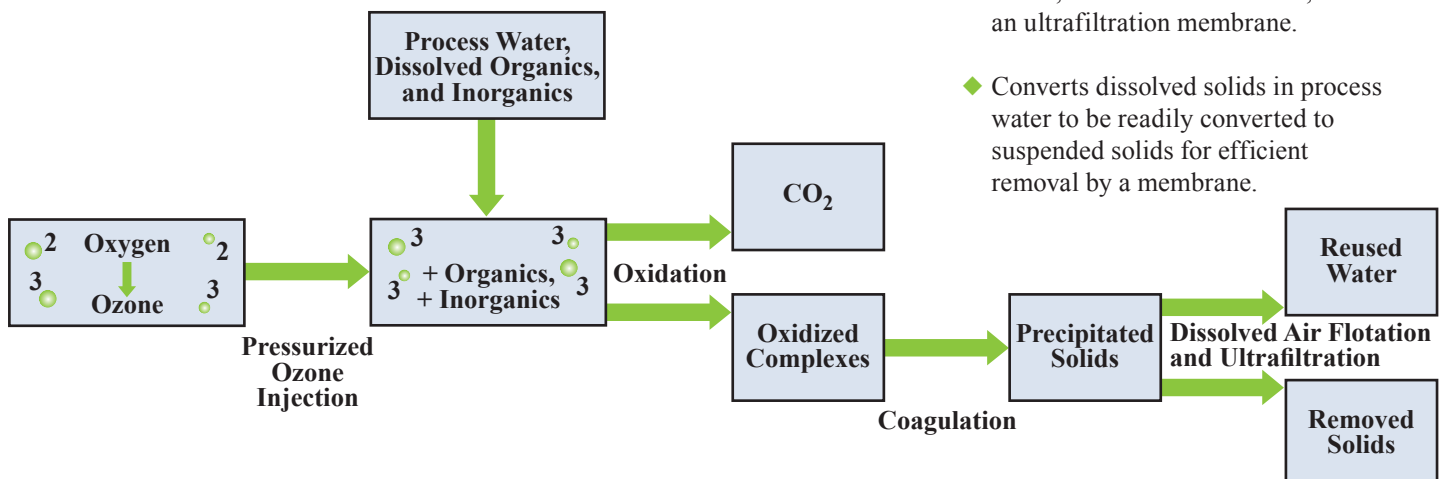
Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.037	5.0

Applications

Can be used in the pulp and paper industry and in other processes such as the food industry, which require filtration technology

Capabilities

- ◆ Uses a series combination of pressurized ozone, dissolved air flotation, and an ultrafiltration membrane.
- ◆ Converts dissolved solids in process water to be readily converted to suspended solids for efficient removal by a membrane.



Pressurized Ozone/Ultrafiltration Membrane System

Thermodyne™ Evaporator – A Molded Pulp Products Dryer

IMPACTS

Thermodyne Evaporator–A Substantially Improved Molded Pulp Products Dryer

With assistance from DOE's Inventions and Innovation Program, Merrill Air Engineers demonstrated that its Thermodyne dryer outperforms conventional molded pulp dryers. Unlike other dryers, the Thermodyne dryer reheats water vapor released from the product being dried to create superheated steam that is directed onto the material being dried. Conventional paper dryers exhaust this liberated water outdoors, causing a large visible plume and dumping valuable heat. The Thermodyne dryer is sealed so internal vapor (moisture) cannot escape into the insulated dryer walls. The retained water vapor passes through indirect integral heaters to raise its temperature to a level that allows for substantially faster drying rates than if drying in relatively dry air. An absence of oxygen in the dryer also means the drying temperature can be higher and the retained water vapor can help protect and evenly dry the material. The released water vapor also helps control internal temperatures by mixing with the superheated steam, dropping its temperature to a more desirable level. Finally, the system recovers heat and harmful volatile organic compounds (VOCs) from the dryer's condensate, substantially reducing the amount released into the atmosphere.

Benefits

Energy Savings and Emissions Reductions

Substantially reduces energy requirements by eliminating the thermal energy needed to make up air exhausted from conventional dryers. Uses up to 50% less energy than a conventional dryer with the potential of saving up to 5 million Btu/ton of pulp. Captures volatile organic carbon (VOC) emissions by containing condensable gases.

Productivity

Process promotes easier stacking and wrapping.

Product Quality

The superheated steam-drying environment suppresses oxygen, reducing the chance of scorching or burning the product under higher and faster drying temperatures. Other quality enhancements include less warping, reduced case hardening, and no discoloration.

Profitability

Process promotes lower shipping costs and lowers product losses.

Overview

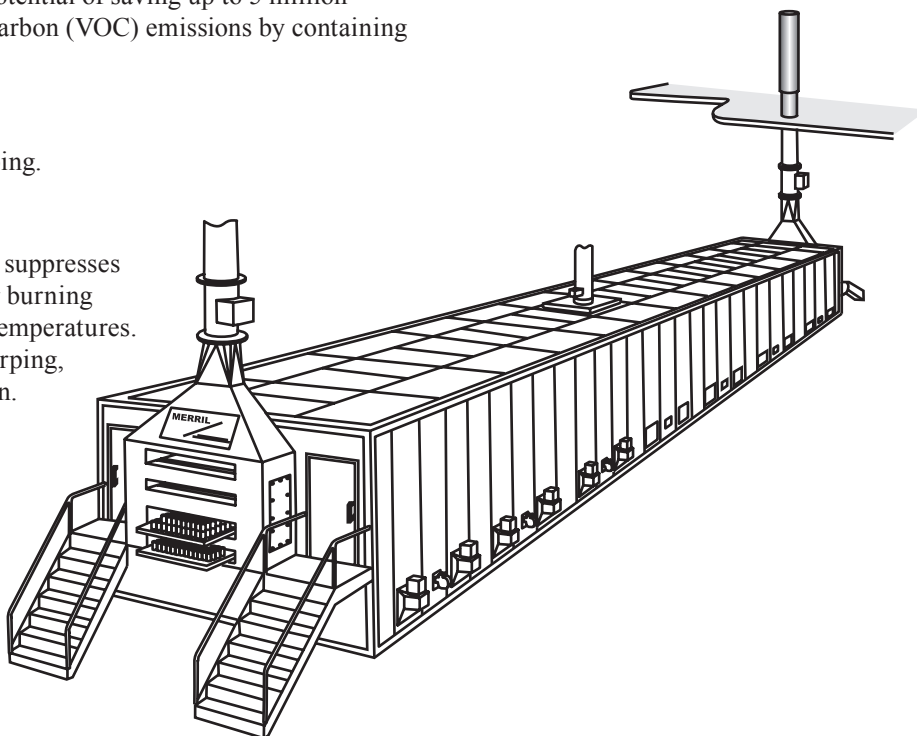
- ◆ Developed by MBA Polymers in 1995
- ◆ Developed by Merrill Air Engineers
- ◆ Commercialized in 1997
- ◆ 1 unit operating in Yakima, WA and 1 in Ireland

Applications

Forest products industry for manufacturing molded fiber articles and for drying pulp, wood, cotton, cellulose, or torrefied wood and wood veneers

Capabilities

- ◆ Fully capable of replacing conventional drying systems in the forest products industry.
- ◆ Handles a wide variety of forest products and can be applied to agricultural applications.



Thermodyne Evaporator–A Molded Pulp Products Dryer

XTREME Cleaner™ – Removal of Light and Sticky Contaminants

IMPACTS

Centrifugal Cleaner Removes Light and Sticky Contaminants from Waste Paper

Americans now recover 45% of all paper used in the United States. Some brown paper grades, wax curtain-coated board, polyethylene-laminated paper, glue-containing magazine backs, and other secondary fiber sources contain contaminants like “stickies,” wax, polyethylene, and binding glue that either make recycling impossible or cause an array of operating or product-related problems. Until recently, the technology for removing the contaminants was not completely effective. The development of the XTREME Cleaner, a centrifugal cleaner that replaces conventional dispersion systems in paper mills using waste paper, was a major breakthrough.

The XTREME Cleaner removes lightweight debris in all types of pulp slurries. It uses long residence times in a small-diameter cleaner to maximize separating very small contaminants that are close to the specific gravity of the fiber itself. Coupled with an advanced design through-flow cleaner such as the XX-Clone™, in the tailing position, only two stages are needed to minimize fiber loss and maximize contaminant removal efficiency. The XTREME Cleaner uses 50% less energy than conventional dispersion systems, resulting in significant cost savings to paper mills. The cleaner allows paper mills to use lower-grade, lower-cost furnish without compromising the quality of the final paper product. Paper mills using the cleaner system have reported savings of \$3,500 to \$11,000 per day just by using the lower-grade furnish.

Benefits

Environmental

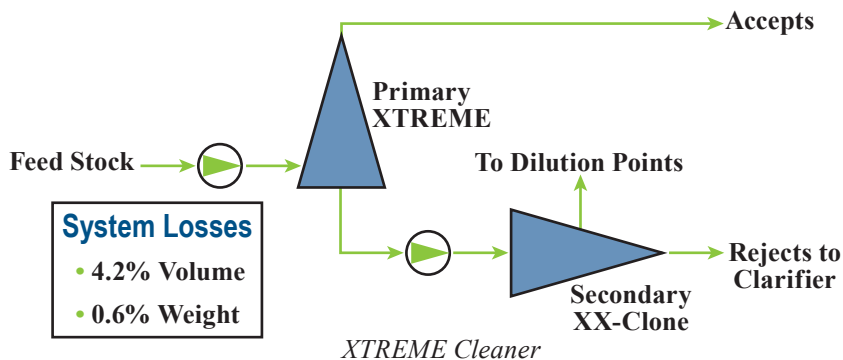
Greatly reduces the amount of waste paper being landfilled. Uses fewer chemicals and less energy to process recycled paper than does producing paper from raw wood material.

Productivity

Produces a 40% to 60% reduction in machine breaks or paper breaks, which are costly to paper mills due to downtime. Eliminates downtime to clean sticky contaminant buildup from processing machinery.

Product Quality

Allows paper mills to use a lower-grade, lower-cost furnish while still producing the same or higher-quality end product. Removes contaminants so they do not contaminate the final product and cause product rejects.



Overview

- ◆ Developed by Thermo Black Clawson
- ◆ Commercialized in 1997
- ◆ 11 systems operating in the United States

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
1.19	0.183

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.001	0.039	0.029	3.59

Applications

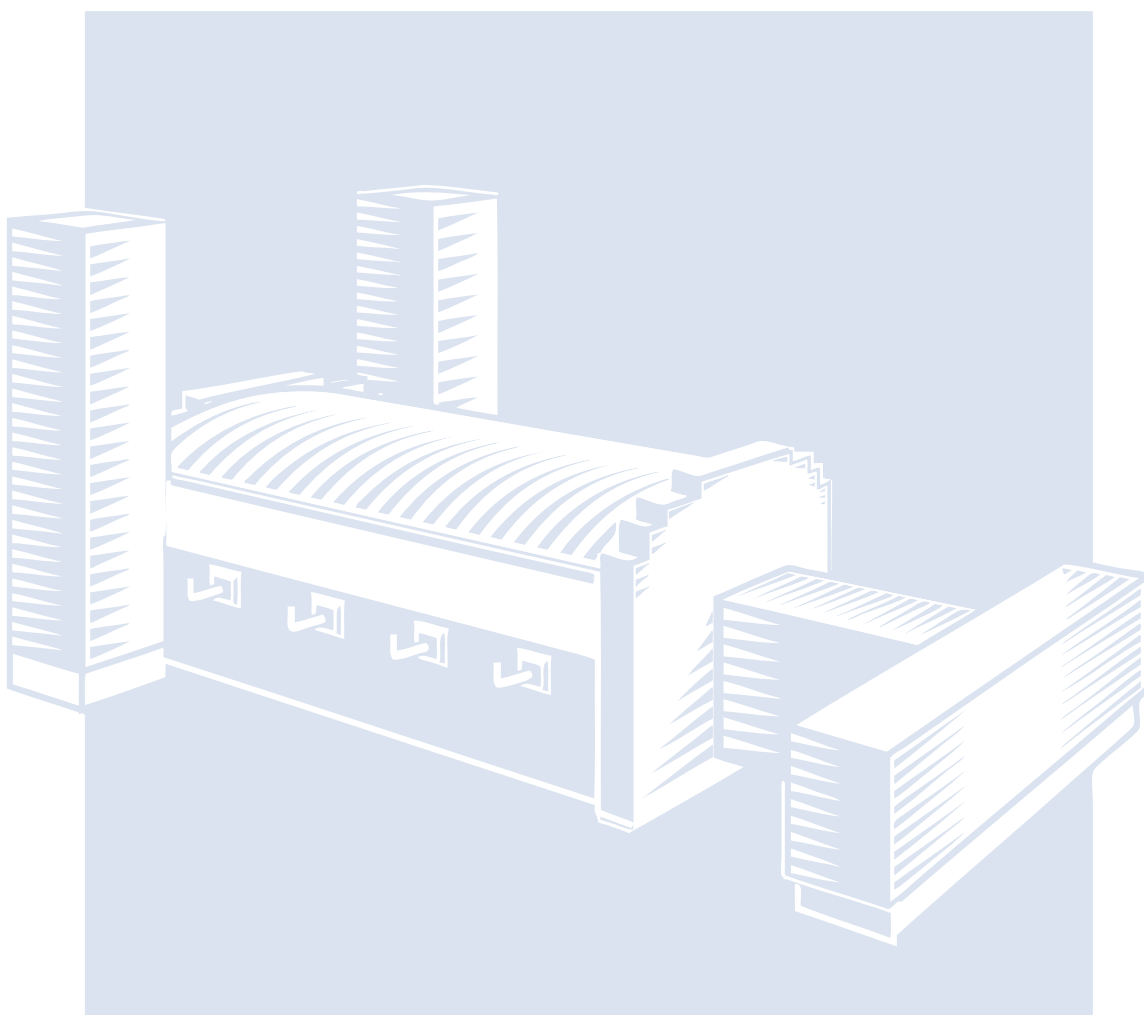
Used in paper mills to recycle waste paper containing “stickies,” wax, polyethylene, and binding glue

Capabilities

- ◆ Effectively removes lightweight sticky contaminants from all types of pulp slurries.
- ◆ Improved kneading, or “liberation”, unit better detaches and separates impurities from waste paper fibers.
- ◆ Improved vortex separation device allows greater unit capacity, longer treatment times, and more consistent operation.

IMPACTS

◆ Advanced Temperature Measurement System	44
◆ High Luminosity, Low-NO _x Burner.....	45
◆ Oxygen-Enriched Air-Staging (OEAS) Technology	46



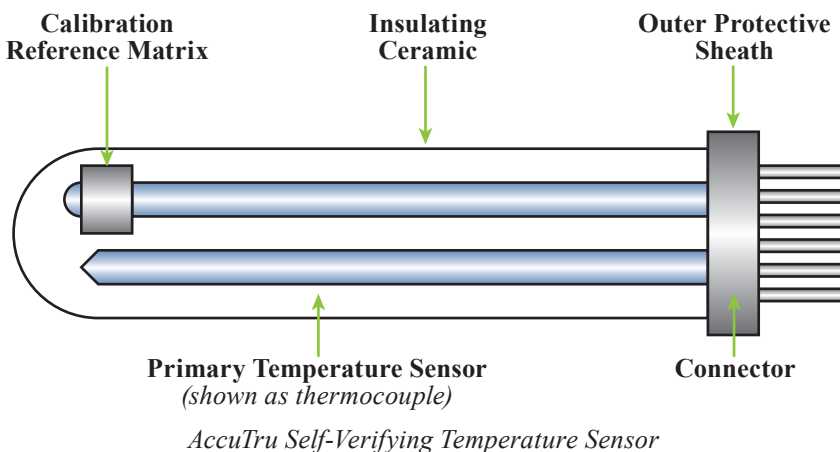
New Material Leads to Development of Improved Monitoring Equipment

Self-validating sensor technology, developed by Accutru with support from ITP, is based on the ability to measure multiple, mutually exclusive thermoelectric properties of thermally sensitive materials contained in the tip of the sensor probe. The sensor probe is constructed like a thermocouple or RTD but is specially designed so that the thermal response of each element of the sensor can be monitored using independent combinations with multiple other elements. The signal conditioner/transmitter multiplexes these measurements and monitors the health of each individual thermo-element using at least two of its electrical properties.

This concept makes it possible to continuously monitor and “validate” each of the measuring elements inside the sensor while it is in service so that no element can drift without detection. If an individual element begins to drift or de-calibrate for any reason, the system eliminates the data for that element while still providing an accurate NIST traceable temperature with the remaining “healthy” elements. Using information about the number of “healthy” elements in the sensor, the transmitter then provides the operator or control system with sensor health status and notifies of impending loss of sensor validation before it occurs. Therefore an accurate and reliable temperature is reported for the life of the sensor.

Summarizing the features of this technology:

- 1) It uses a new concept of monitoring multiple independent measurements of the system temperature and individual element health,
- 2) it continuously validates and reports the system temperature,
- 3) it reports a temperature traceable to a NIST standard for the life of the sensor,
- 4) it reports the health of the sensor, and
- 5) it warns in advance of deterioration of any of the sensor elements.



Overview

- ◆ Developed by AccuTru International, Kingwood, Texas
- ◆ Commercialized and marketed by AccuTru
- ◆ 45 units currently operating in the United States

Applications

Any thermochemical process where accurate and repeatable temperature read out is important:

- u glass melters and delivery systems
- u chemical reactors
- u heat treating
- u gas turbines

Capabilities

- ◆ Separates as many as three different plastics at one time in a mixed waste stream.
- ◆ Reliable temperature range: -200°C to 1750°C
- ◆ Self-validating, while in service for the life of the sensor
- ◆ Warning on the onset of decalibration, predictive maintenance agricultural applications.

Benefits

Optimizing Process Yield

- ◆ Improved fuel efficiency
- ◆ Enhanced safety
- ◆ Extended equipment life

Productivity

- ◆ 90% reduction in QC failures
- ◆ 10% increase in annual yields

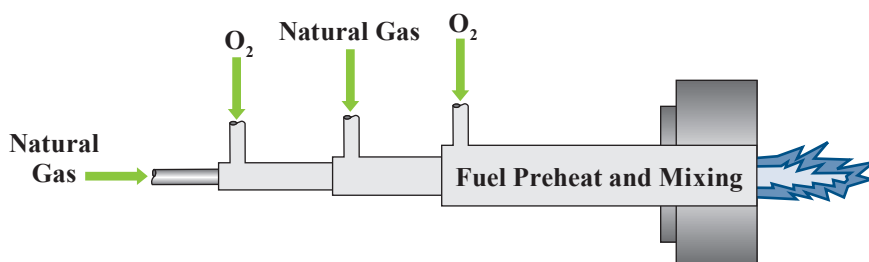
IMPACTS

High-Efficiency Burner Lowers Costs and Emissions in Oxy-Fuel Glass Melters

Glass melters use combustion systems to produce molten glass. While significant progress has been made in developing oxy-fuel combustion systems, current technologies provide low flame luminosity and generate relatively high NO_x emissions in the presence of even small mounts of nitrogen in the combustion process.

With the help of a grant from ITP, Combustion Tec Inc. has developed an innovative burner that increases luminosity and radiant heat transfer in high-temperature glass furnaces. The burner improves performance by modifying the fuel prior to combustion and then forming and burning soot in the flame. The burner increases heat transfer rates while decreasing flame temperatures to improve furnace production rates and thermal efficiency.

The high-luminosity, low-NO_x burner combines a preheating zone with two combustion zones. First, a small fraction of the natural gas is burned. The products of this combustion are then mixed with the main supply of natural gas, resulting in hydrocarbon soot precursors generated in an oxygen-free heating environment. Next, the preheated natural gas enters the first, fuel-rich combustion zone in which soot forms in the flame. However most of the combustion occurs in the second, fuel-lean combustion zone. The burning soot particles create a highly luminous flame that is more thermally efficient and cooler than a typical oxy-fuel flame.



High Luminosity, Low-NO_x Burner Design

Overview

- ◆ Developed and marketed by Combustion Tec, Inc.
- ◆ Commercialized in 2002
- ◆ Operating in two U.S. plant in 2004

Applications

Existing and new oxy-fuel glass melters. The largest demand currently exists in the container, fiber, and specialty glass sectors of the glass industry

Capabilities

- ◆ Can clean tanks with capacities up to 2,300 gallons.
- ◆ Can be used on new furnaces or retrofit to older ones.
- ◆ Improves furnace production rates as a result of a more than 12% increase in heat transfer rates.

Benefits

Energy Saving and Pollution Reduction

The high luminosity burner technology reduces NO_x emissions from glass melters up to 50% and improves thermal efficiency up to 20% over traditional oxygen fuel burners.

Productivity

The improved burner allows cost-effective compliance with emissions regulations. The technology also provides flexibility for compliance in existing furnaces without major modifications.

Reliability

The technology produces a lower flame temperature and lower exit temperatures, which could extend the furnace life.

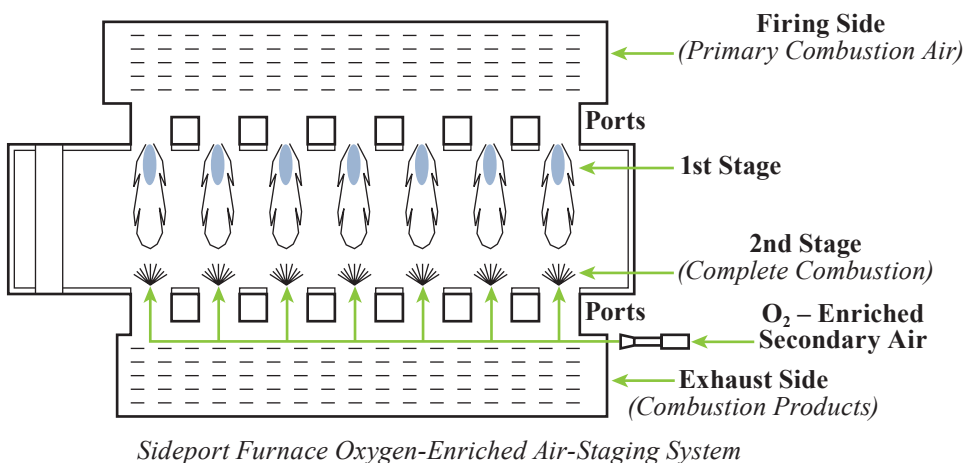
Oxygen-Enriched Air-Staging (OEAS) Technology

IMPACTS

NO_x Emissions Reduced for Glass Furnaces Using New Technology

Glass furnaces are facing very stringent environmental regulations with respect to NO_x emissions. ITP has provided support to the Institute of Gas Technology and Combustion Tec to develop and commercialize the OEAS to help meet these new regulations. The OEAS system reduces the available oxygen in the flame's high-temperature zone and improves flame-temperature uniformity. This process controls NO_x formation and improves heat transfer to the glass without interrupting furnace operation or adversely affecting product quality. The system stages combustion by holding back a portion of the combustion air normally provided during the earlier stages of combustion and flame development. This results in a minimum of excess air or even a fuel-rich operation that impedes NO_x formation. The resulting flame is hotter and more luminous, resulting in higher flame luminosity, which translates to improved overall melting efficiency. By injecting air into the combustion space before the exhaust port, the CO formed earlier is burnt off. At this point, although the amount of free oxygen is higher, the lower flame temperature prevents NO_x formation. The overall air-fuel ratio is similar to what is to be found in a conventionally fired furnace, and, therefore, glass redox is not affected.

The OEAS technology has been successfully retrofitted to endport furnaces in the United States and has achieved NO_x levels below 2 lbs per ton (40% to 70% reduction). Efforts are currently underway to apply this technology to sideport furnaces that account for 65% of current glass production.



Overview

- ◆ Developed by the Institute of Gas Technology
- ◆ Marketed by Eclipse, Inc.
- ◆ Commercialized in 1994
- ◆ 6 units operating in the United States

Applications

Endport and sideport regenerative glass furnaces

Capabilities

- ◆ Creation of oxygen-deficient primary flame inhibits NO_x formation.
- ◆ Air or oxygen-enriched air is injected at strategic locations downstream to complete the combustion process.
- ◆ NO_x is reduced from 40% to 75%.
- ◆ The process does not affect the furnace operation.

Benefits

Reduced Costs

Capital and operating costs are moderate for this process compared to competitive technologies, making it a cost-effective choice. Additionally, the technology will reduce the cost of producing oxygen.

Reduced Emissions

NO_x levels associated with the glass melting process will be reduced by 40% to 70%, enabling glass producers to meet more stringent environmental regulation.

Reduced Waste

Total waste production is expected to be reduced by 10,000 tons per year, a 31% reduction.

Metal Casting

IMPACTS

◆ Ceramic Composite Die for Metal Casting.....	48
◆ Die Casting Copper Motor Rotors	49
◆ Simple Visualization Tools for Part and Die Design	50



Ceramic Composite Die for Metal Casting

IMPACTS

New Ceramic Composite Materials to Produce Superior, Low Cost Dies

Metalcasting, a major U.S. industry, has long been hampered by the high cost and short life of casting dies. Steel dies often fail prematurely due to metal fatigue cracking, corrosion, erosion, oxidation, heat checking, and soldering when the dies are exposed to molten metals while operating under cyclic-mechanical and thermal loading.

For some applications, coatings are applied to protect the die from the damage inflicted by molten metals. However, these coatings can fail prematurely and tend to interfere with the welding and polishing operations needed during reworking and correcting damages in the die.

With assistance from DOE's Inventions and Innovation Program, the Materials and Electrochemical Research Corporation has developed ceramic composite materials as an alternative to conventional material used in forming casting dies. Ceramic composites can deliver proven stability to molten metals and are resistant to corrosion, erosion, oxidation, thermal fatigue, and cracking. In addition, lower-cost hybrid composites in the nitride/nitridecarbide family have the potential to last up to 10 times longer than coated steel dies with significantly lower weight. These new composites are expected to reduce the cost of many products fabricated in the United States and create stronger competitiveness in the domestic metalcasting industry.

Benefits

Productivity

The composite dies weigh approximately one-third less than traditional tool steel dies. The weight reduction saves time in production by eliminating some of the mechanical moving equipment.

Waste Reduction

The longer life of ceramic dies reduces the amount of waste produced by failed tool steel casting dies. The ceramic dies also produce fewer casting rejections, reducing the energy needed to recycle the rejected castings.

Overview

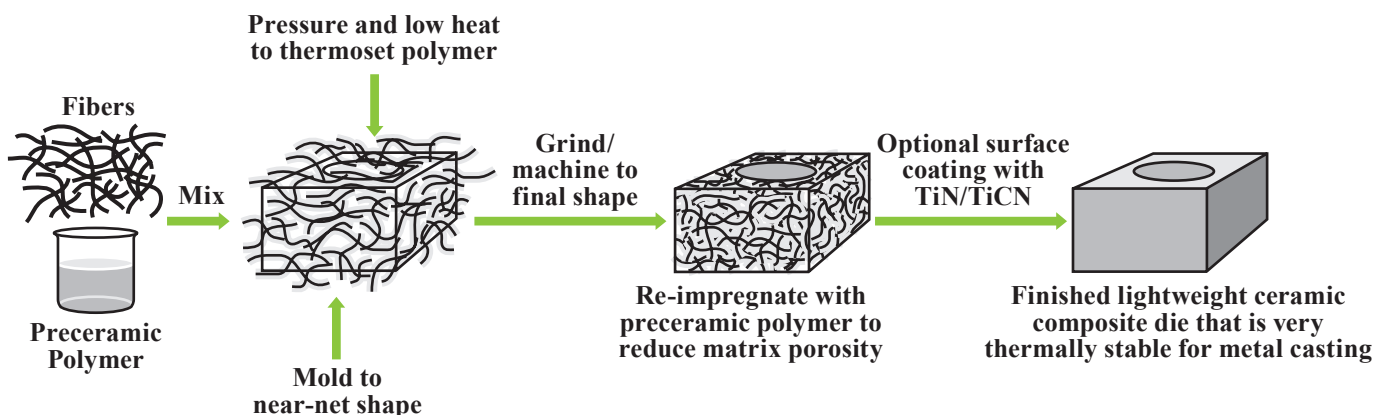
- ◆ Invented by the Materials and Electrochemical Research Corporation
- ◆ Commercialized in 2002
- ◆ Installed in several U.S. locations

Applications

Dies for metal casting, including replacement dies that are currently tool steel

Capabilities

- ◆ Offers resistance to corrosion, erosion, oxidation, thermal fatigue, and cracking.
- ◆ Provides stability when exposed to molten metals.
- ◆ 2 to 5 times harder than tool steels, resulting in 5 to 10 times longer useful die life.



Ceramic Composite Die Forming Process

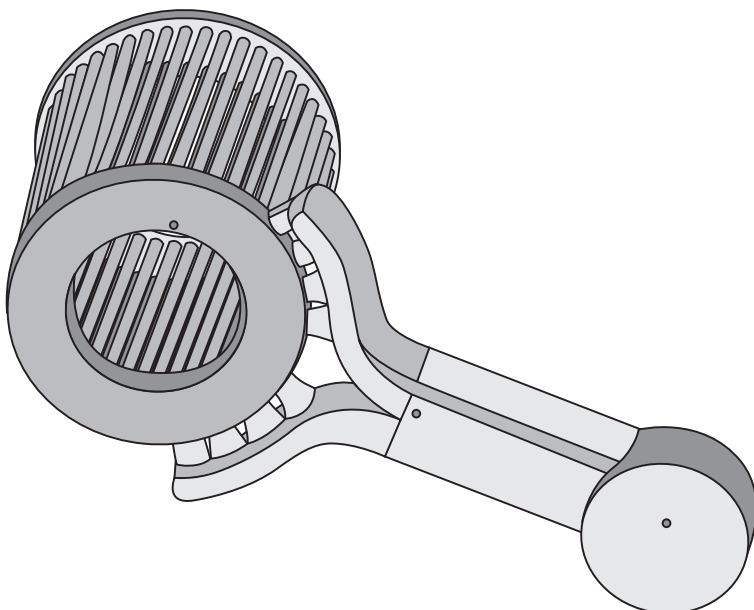
IMPACTS

Die Casting Copper Technique Improves Energy Efficiency of Electric Motors

Though it conducts electricity less efficiently than copper, aluminum is the industry's preferred fabrication material in electric induction motor rotors. Traditional tool steel casting molds suffer thermal shock, shortening model life and increasing operating costs when used for die casting copper rotors. ThermoTrex Corporation, with the assistance of a NICE³ grant, proposed a process for copper die casting using molds from high-temperature, thermal shock-resistant materials. The copper industry successfully tested these mold materials for copper die casting at higher temperatures (copper melts at 1083°C, aluminum at 660°C).

The copper die-casting technology developed by the copper industry is now in commercial use. The process replaces the tool steel molds used for the aluminum die casting with molds made from high-temperature die materials. In addition, the new process preheats the die inserts, reduces the temperature differential between the mold surface and the cooler interior, and avoids mold failure from thermal shock and thermal fatigue.

In 2003, SEW Eurodrive of Bruchsal, Germany, was the first company, worldwide, to bring the technology to market. A line of high-efficiency gear motors (1.1-5.5 kW) use copper rotors at a competitive price. Because traditional high-efficiency motors are larger than standard motors, gear boxes using copper rotor technology provide efficiency without increasing motor size. In 2004, FAVI S.A., a major French supplier of copper and copper alloy die castings, began offering custom-designed, copper-based rotors for squirrel-cage electric motors in sizes ranging from fractional to 100 hp.



Squirrel-Cage Motor with Die Cast Copper Rotors

Overview

- ◆ Invented by the ThermoTrex Corporation and commercialized by the Copper Development Association
- ◆ Marketed by SEW Eurodrive and FAVI S.A.

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.091	0.085

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.018	0.014	1.68

Applications

Electric motors are used throughout the United States industry and account for more than 60% of all electricity use in the nation. The annual market for electric motors totals about \$35 billion internationally and about \$10 billion in the United States.

Capabilities

- ◆ Improves motor efficiency by 15% to 20%.
- ◆ Decreases operating costs compared with conventional motors.

Benefits

Productivity

The new technique reduces production time and hand labor compared with former methods of producing copper motor rotors.

Profitability

Motors using copper rotors decrease operating costs compared with conventional motors.

New Software Program Helps Detect Potential Design Problems in Die Casting

With funding from DOE and the North American Die Casting Association (NADCA), a software program has been developed that offers a simple qualitative method to visualize potential design problems in diecasting. CastView™ is a PC-based modeling program for die casting flow simulation. It is based on a qualitative analysis of part geometry that yields extremely fast analysis times. The program uses imported STL files so a solid model does not have to be constructed. The user can select gate sizes and locations, and the program provides a visualization of how the die cavity fills. A typical analysis can be made in a matter of minutes, making multiple iterations quick and manageable. A “thickness” feature allows the user to find the thickest and thinnest sections of the casting geometry quickly and visualize the first and last area to solidify.

Using a standard computer interface and intuitive viewing controls, CastView points casting and die designers to the potential problem areas they may want to focus on using a more detailed, mathematically-based simulation program. CastView is an excellent front-end complement to the commercially available, mathematically-based computer modeling programs.

Benefits

Energy and Environmental Savings

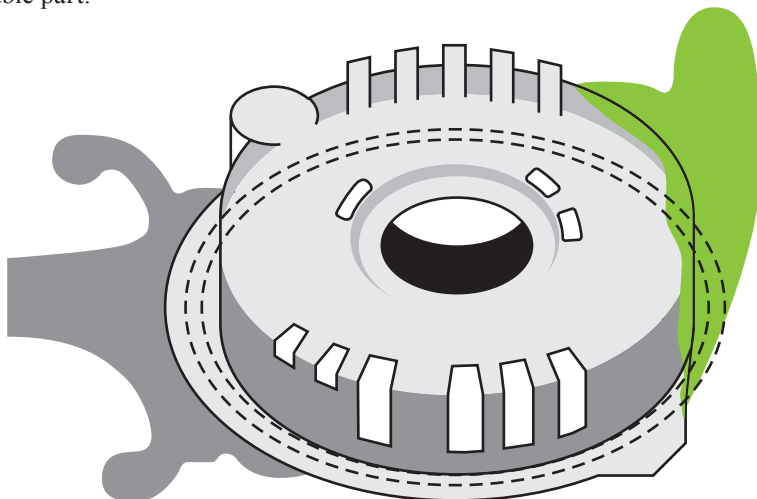
Process scrap can be reduced by 20% or more, resulting in increased yield and saving the energy formerly wasted producing defective parts.

Productivity

By promoting compatibility between die casting part and die design, part development lead-time and tryout/setup time can be reduced significantly.

Profitability

Detecting problems early in the process enables the die caster to negotiate a modification of the part geometry with the part designer to achieve a more castable part.



CastView Pattern

Overview

- ◆ Commercialized by the North American Die Casting Association
- ◆ Commercialized in 1999
- ◆ 123 units sold to date

Applications

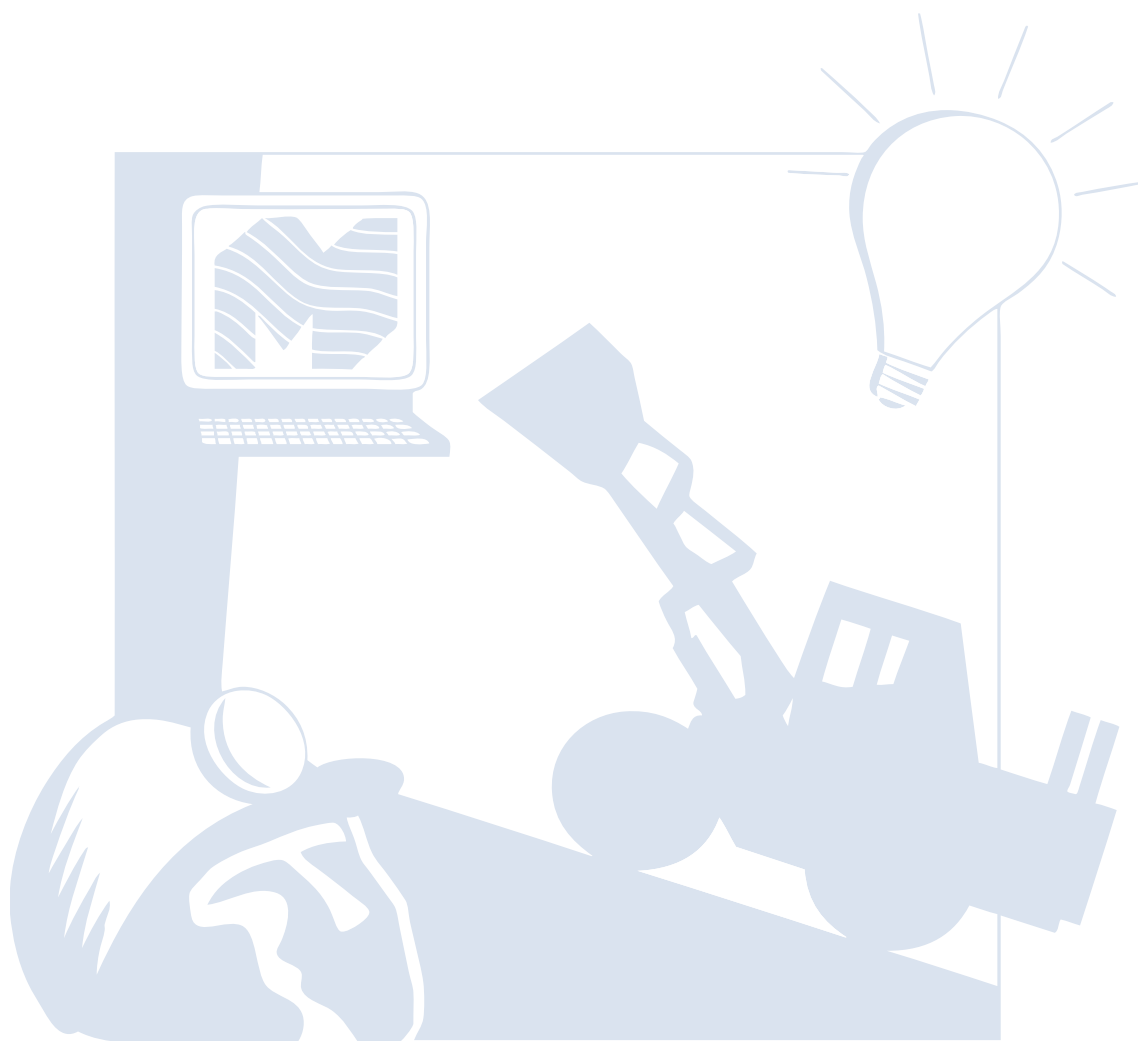
CastView can be used in the die casting industry by both designers and die casters to visualize, identify, and resolve potential die casting design problems while still in the design stage

Capabilities

- ◆ Improves communications between die casters and designers.
- ◆ Allows quick evaluations of a large number of design alternatives.
- ◆ Locates and displays thick and thin sections in the die.
- ◆ Minimizes flow-related filling problems.
- ◆ Minimizes thermal problems in the casting die.
- ◆ Minimizes solidification-related defects in the cast part.
- ◆ Allows more and easier to use controls for the rotation of the part for all views.
- ◆ Provides functions to test for bad STL files thus eliminating many problems associated with bad data.
- ◆ Includes print and save functions so that the analysis results can be recorded as bitmaps for use in other programs and documents.
- ◆ Includes an expanded animation function that includes slice mode animation allowing operator to automatically produce a sequence of slices through the part.

IMPACTS

◆ Fibrous Monoliths as Wear-Resistant Components	52
◆ Horizon Sensor™	53
◆ Imaging Ahead of Mining	54
◆ Smart Screening Systems for Mining	55
◆ Wireless Telemetry for Mine Monitoring and Emergency Communications	56



Fibrous Monoliths as Wear-Resistant Components

IMPACTS

New Composite Material Improves the Cost/Performance Ratio of Drill Bits

Advanced Ceramics Research (ACR) led a collaborative effort of component manufacturers, end users, a national laboratory, and universities to develop fibrous monoliths (FMs) for mining applications. ACR licensed the technology to Smith Bits of Houston, Texas, one of the world's largest oil and drill bit manufacturers. Smith Bits demonstrated nearly a 3 to 1 oil drilling performance increase using FM technology compared with state-of-the-art diamond-coated drill bits. ACR also started a joint commercialization program with Kyocera Corporation to apply FM technology to industrial cutting tools.

Smith Bits uses the FM composites in Cellular Diamond™ inserts for drilling and high-impact applications. FMs are produced using a simple process in which sets of inexpensive, thermodynamically compatible ceramic and/or metal powders are blended with thermoplastic polymer binders and then co-extruded to form a green fiber. The green composite fiber is extruded and thermoformed into the shape of the desired component, pyrolyzed to remove the polymer binder, and consolidated at ultrahigh pressure and temperature to obtain the final FM product. The new FM manufacturing process produces ultra-hard inserts for roller cone bits.

Overview

- ◆ Collaboratively developed by a collaboration of a national laboratory, universities, and private companies led by Advanced Ceramics Research, Inc.
- ◆ Currently licensed to Smith Bits, a subsidiary of Smith International, Inc., for use on drill bits

Applications

Wear-resistant components for drilling

Capabilities

FM composites have very high fracture energies, damage tolerance, and graceful failure.

Benefits

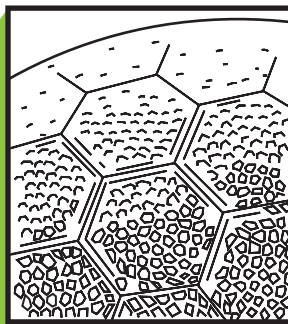
Energy Savings

Reduces energy consumption by more efficient use of the drill machinery and less downtime.

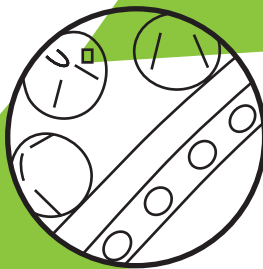
Productivity

Increases the cost/performance ratio of wear materials and components and increases employee output.

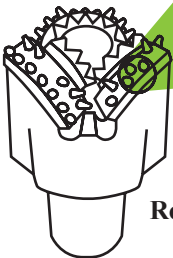
Closeup of Fibrous Monolith Microstructure



Detail of Blowup



Roller Cone Drill Bit



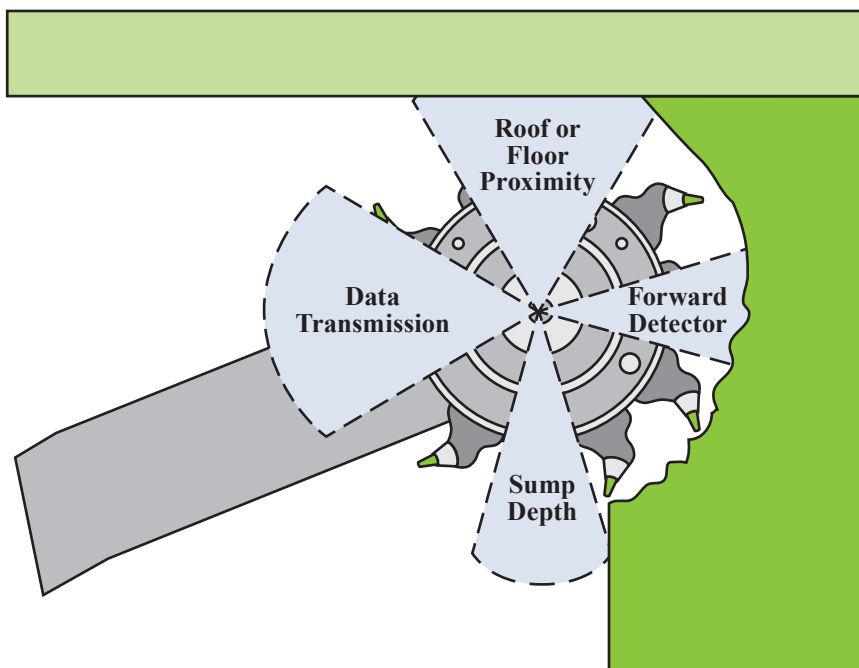
Roller Cone Drill Bit with Fibrous Monolith Inserts

IMPACTS

Remote Sensing Cuts Coal and Other Minerals More Efficiently

Future mining will be from deeper and thinner seams; profiles of deep coal seams reveal multiple levels of coal and sediment strata or layers. Some of these layers contain greater levels of pollutants than others, which results in more effort to clean the coal once it is removed from the ground and more emissions when it is burned for fuel.

With the aid of a DOE grant, Stolar Horizon, Inc., developed the Horizon Sensor to distinguish between the different layers of coal. Miners can use this technology at remote locations to cut only the clean coal, resulting in a much more efficient overall process. The sensor, located inches from the cutting bits, is based on the physics principle of resonant microstrip patch antenna (RMPA). When it is in proximity of the rock-coal interface, the RMPA impedance varies depending on the thickness of uncut coal. The impedance is measured by the computer-controlled electronics and then is sent by radiowaves to the mining machine. The worker at the machine can read the data via a graphical user interface, which displays a color-coded image of the coal being cut, and direct the machine appropriately.



Functions Performed by the Horizon Sensor Mounted on the Cutting Edge of a Continuous Mining Machine

Overview

- ◆ Developed by Stolar Horizon, Inc.
- ◆ Commercialized in 2002
- ◆ Used in 10 different mines within the United States

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.169	0.072

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.015	0.012	1.41

Applications

Both underground and surface mining operations. This technology is primarily used in the coal industry but is also used to mine trona and potash.

Capabilities

- ◆ Improves the quality of coal extracted from mines.
- ◆ Allows for deeper mining.
- ◆ Is used remotely for miner safety.

Benefits

Productivity

Extracting only desired material increases productivity by reducing or eliminating the cleaning step after extraction. This technology also allows for deeper mining, resulting in more material obtained from one location. Also, keeping the cutting bits out of rock results in longer bit life.

Safety

The remote sensing tool allows workers to operate the machinery away from the hazards of cutting coal, including noise, dust and gases, and coal and rock splintering and outbursts.

Radio-Imaging Method (RIM™) Improves Mine Planning and Products

Coal mining is becoming more difficult as machines must extract the coal from deeper, thinner, and more geologically complex coal beds. This type of mining also includes the need to reduce risk and costs.

To address these mining issues, Stolar Horizon, with support of a DOE grant, redesigned and improved a technology developed twenty years ago. The Radio-Imaging Method (RIM™) uses wireless synchronization between a transmitter and remote imaging receiver to detect geologic formations up to 1,800 feet ahead.

In layered sedimentary geology, a natural coal seam waveguide occurs because of the 10:1 contrast in conductivities between coal and surrounding materials. The electromagnetic wave sent by RIM through the rock reacts to these properties with a detectable change in magnitude because it is very sensitive to changes in the waveguide geology.

The information from RIM can be used to produce an image that maps out the dikes, faults, and paleochannels for more targeted mining. Areas of high signal loss represent geologic anomalies and can be imaged to high resolution using tomographic reconstructions similar to CAT scans.

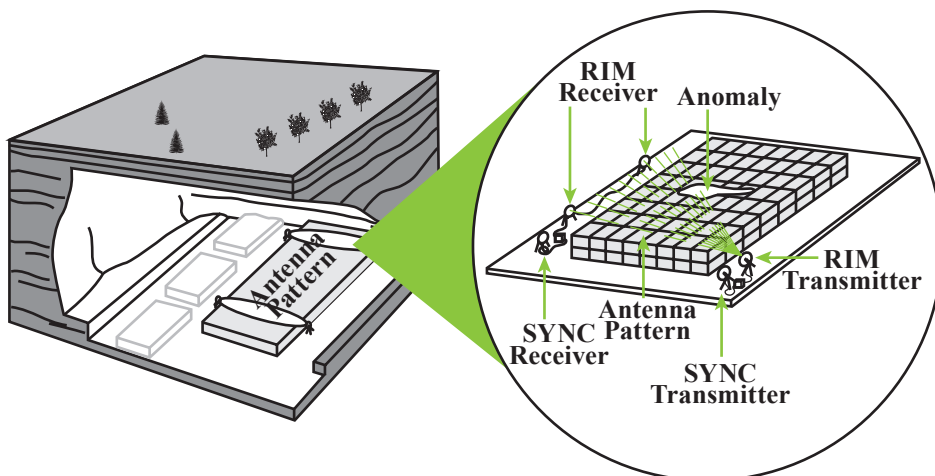
Benefits

Energy Savings

Being able to drill in targeted areas and to extract cleaner coal is expected to reduce energy use 2.7 trillion Btu/yr by 2020.

Productivity and Profitability

In mining, forward imaging with confirmation will reduce the risk of interrupting production because of adverse geologic conditions. When RIM is integrated into the planning of underground mining, forecasting production can improve 10 percent, which in turn increases profits.



In-Mine RIM Detection System

Overview

- ◆ Developed by Stolar Horizon, Inc.
- ◆ Commercialized in 2002
- ◆ Used in 6 different mines through 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
4.10	1.64

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.007	0.354	0.264	32.2

Applications

Both underground and surface mining operations. This technology is primarily used in the coal industry but has also been used for metalliferous mining, environmental research, and civil engineering applications. Additionally, it has been used to confirm the location of old and abandoned mine works and the integrity of barriers.

Capabilities

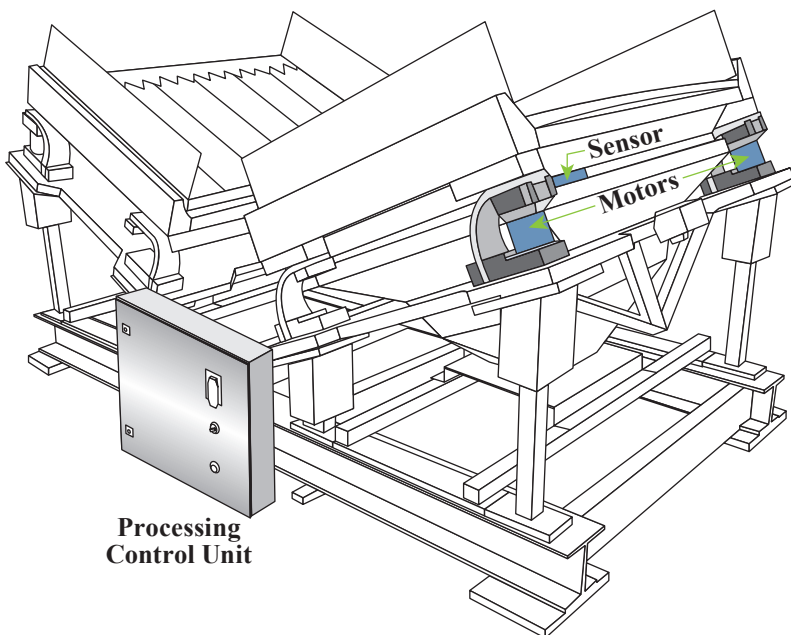
- ◆ In-mine RIM detects ore seams and geologic anomalies.
- ◆ Crosswell RIM delineates ore bodies, monitors heap leaches, and detects voids in coal seams.
- ◆ Drillstring radar for navigation detects voids and confirms geologic anomalies.

IMPACTS

Smart Screening Systems Will Increase Energy Efficiency And Throughput

In mining, contemporary vibrating screening machines use an electrical motor with an eccentric rotor that generates the shaking motion. These unbalanced electrical rotors are bulky and have high maintenance costs. They also waste significant energy through useless elastic deformation of heavy supporting structure and generate very loud noises and excess heat. Excess heat and mechanical vibration reduces the life of the moving components, such as bearings.

With assistance from ITP, Quality Research, Development, and Consulting (QRDC), Inc., developed a Smart Screening System that controls the flow of energy by directing and confining the energy to the screen rather than shaking the entire support structure. The system saves energy by replacing the massive electrical motor and eccentric shaft, which typically weighs around 1,100 lbs, with miniaturized “smart” motors that weigh only 5 lbs in combination with multi-staged resonators. The processing control unit continuously receives screen panel deflection data taken from the sensor to control the electromagnetic motors. The motors are programmed to vibrate the screening panel at an optimal set rate, even as the material load varies over time, thus optimizing the throughput and energy savings of the screening system. Future designs may incorporate ceramic fibers in sieves so the shaking takes place at the mesh level, further focusing energy in such a way that particles will have a greater opportunity to pass through the openings.



Smart Screening System Components

Overview

- ◆ Developed by QRDC and manufactured and sold by Smart Screening Systems, Inc.
- ◆ Commercialized in 2003
- ◆ 24 systems operating in the United States in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.002	0.001

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.0	0.029

Applications

All mined materials that must pass through a positive size separation process using vibrating screens.

Capabilities

- ◆ Vibrates only the “live” system components rather than the entire machine and supporting structure in the material separation process.
- ◆ Allows for a smaller physical structure to achieve a given process objective.

Benefits

Operation and Maintenance

Reduces maintenance costs in screening operations and eliminates the need for lubrication.

Productivity

Improves screening efficiency and capacity as well as overall process throughput.

Safety

Reduces noise and vibration levels increasing worker safety and health.

Wireless Telemetry for Mine Monitoring and Emergency Communications

IMPACTS

Replacing Communication Cables Improves Safety, Efficiency, and Cost of Mining

The hard-wired systems currently used in mining to transmit production data, environmental monitoring data, and voice signals to the surface are not reliable in emergency situations because of shifting debris or other hazards. To solve these critical problems, a wireless, through-the-earth telemetry system has been developed with the assistance of DOE's Inventions and Innovation Program. The system eliminates the need for wire connections between the surface and mining sites underground.

In addition to improving safety for underground workers, such a system would be more reliable, useful, cost effective, and flexible. For example, if the new system is combined with a separate in-mine system, workers could communicate freely with other underground personnel as well as surface personnel. By using the wireless transmitters, mining operations would not need to invest in communications cables and their installation and maintenance.

Reports from installations in U.S. mines indicate that the technology is a significant source of cost and maintenance savings.



Wireless Telemetry Communication System

Overview

- ◆ Invented by Transtek, Inc.
- ◆ Commercialized in 1998
- ◆ As of December 2004 there are 10 customers using 30 to 40 units in U.S. mines

Applications

- ◆ All mining situations and other underground work
- ◆ Steel-reinforced buildings, tunnels and transit systems

Capabilities

- ◆ Offers greater flexibility and mobility in communications.
- ◆ Allows for continued transmission of production data and environmental monitoring data.
- ◆ Increases communications capabilities both from the surface to the mining site and among personnel underground.

Benefits

Cost Savings

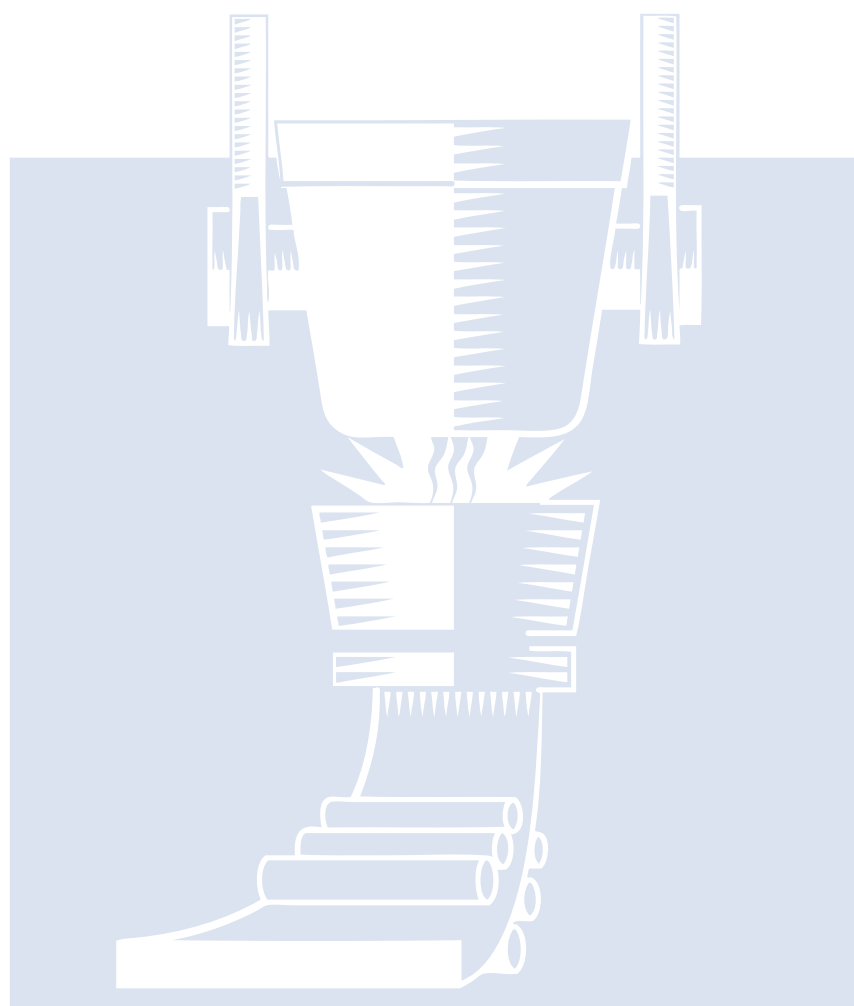
Costs are reduced by up to 25% by eliminating the need to purchase, install, and maintain communication cables. The new reliable system reduces unplanned downtime, thereby also saving costs.

Worker Safety and Health

The new system increases the safety and acceptability of coal mining as an energy source, thereby augmenting the energy supply. Safety in the mine is improved by the system's ability to provide uninterrupted communications.

IMPACTS

◆ Automatic High-Temperature Steel Inspection and Advice System.....	58
◆ Dilute Oxygen Combustion System.....	59
◆ Electrochemical Dezincing of Steel Scrap.....	60
◆ Laser Contouring System for Refractory Lining Measurements	61
◆ Microstructure Engineering for Hot Strip Mills.....	62
◆ Recovery of Acids and Metal Salts from Pickling Liquors	63
◆ Shorter Spheroidizing Annealing Time for Tube/Pipe Manufacturing.....	64
◆ Steel Reheating for Further Processing	65
◆ Transfer Rolls for Steel Production.....	66



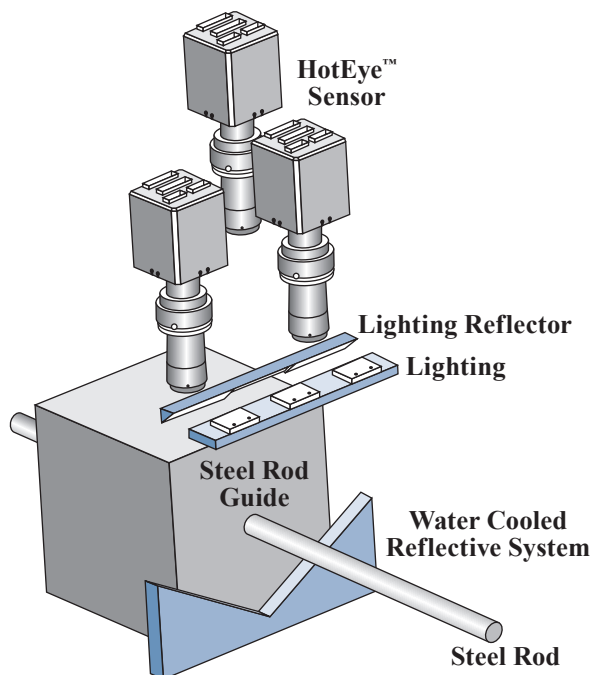
Automatic High-Temperature Steel Inspection and Advice System

IMPACTS

Unique Measurement System Enhances Process Control, Reduces Scrap, and Saves Energy

A new measurement system, the HotEye™ Rolled Steel Bar (RSB) System, has been developed and demonstrated by OG Technologies (OGT) Inc., with the help of a NICE³ grant. The HotEye RSB System is based on OGT's HotEye System and integrates it with a dynamic control plan (DCP) for hot steel processes. The HotEye System accurately and reliably measures a part's dimensions and detect its surface features, including defects, while it is still red hot, i.e. at temperatures of up to 1550°C. Current measurement systems cannot be used until the parts cool down, which results in higher scrap rates once defects are detected. The DCP classifies defects from production and identifies their root causes and corrective actions. The DCP's effectiveness depends on instruments that can detect quantitative quality information in real-time in a hostile operating environment. The HotEye RSB System provides real-time process control to increase yields 2.5% in continuous casting and hot rolling steel mills, saving energy, improving quality, and increasing productivity.

The HotEye RSB System consists of three HotEye imaging sensors, four powerful PC's, modulating devices for the lighting system, proprietary image processing software, the software version of the steel rolling DCP, and an enclosure to protect the hardware and software from the effects of the harsh operating environment in a steel mill. The HotEye RSB System will automatically (1) inspect 100% of the surface of the product in-line; (2) identify defects as small as 0.025 mm; (3) analyze and record the size, nature, and location of the defects; (4) measure 100% of the dimensions of the product; and (5) generate process correction advice based on the DCP, while the product is at a temperature up to 1550°C and moving at a speed up to 100 m/second.



Design of the HotEye RSB Sensor System

Overview

- ◆ Developed by OG Technologies, Inc.
- ◆ Commercialized in 2004
- ◆ Operating in two U.S. steel mills in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.478	0.478

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.056	7.59

Applications

The HotEye RSB System can be used in steel hot rolling mills and continued casting processes

Capabilities

- ◆ Inspects 100% of product surface on-line.
- ◆ Identifies defects as small as 0.025 mm.
- ◆ Performs inspections while the product is at temperature of up to 1550°C and moving at 100 m/second.

Benefits

Employee Safety

Allows the measurement of parts at temperatures of up to 1550° C remotely, reducing employee burns.

Profitability and Productivity

Detects and identifies production flaws quickly and reduces the scrap rate from the process by 50%.

DOE Industrial Technologies Program

Dilute Oxygen Combustion System

IMPACTS

Dilute Oxygen Combustion Improves Reheat Furnace Performance and Provides Very Low NO_x Emissions

The Dilute Oxygen Combustion (DOC) system provides competitive rolling mill operators with higher productivity reheat furnaces without high capital and operating costs or increased NO_x emissions. By replacing combustion air with oxygen, DOC needs less fuel to heat steel and also gives lower flue gas temperatures. These features allow a reheat furnace to operate economically at higher production rates. The DOC system injects the fuel gas and oxygen into the furnace as distinct, high-velocity jets through separate lances rather than through a single burner. The jets mix with the hot furnace gases before reacting with each other. This dilution effect prevents the high peak flame temperatures that are responsible for NO_x generation, providing low NO_x levels even with high nitrogen levels for the furnace. Because the flue gas is recirculated aerodynamically within the furnace, the DOC system is simpler and less expensive to install compared with conventional flue gas recirculation systems. In addition, the wide, diffuse flame from the DOC system provides exceptionally uniform heating of the steel, leading to better rolling mill performance and lower reject rates.

Benefits

Energy Savings

Results in fuel savings of up to 50% over air-fuel combustion for reheat furnaces.

Productivity and Profitability

Increases productivity 10% to 30% over air-fuel combustion with the simple, low-maintenance combustion system. Improves heating uniformity, giving better quality and fewer rejects in rolled products.

Overview

- ◆ Commercialized by Praxair, Inc.
- ◆ Installed in 1999 at Nucor Steel in Auburn, NY

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.042	0.007

Emissions Reductions

(Thousand Tons, 2004)

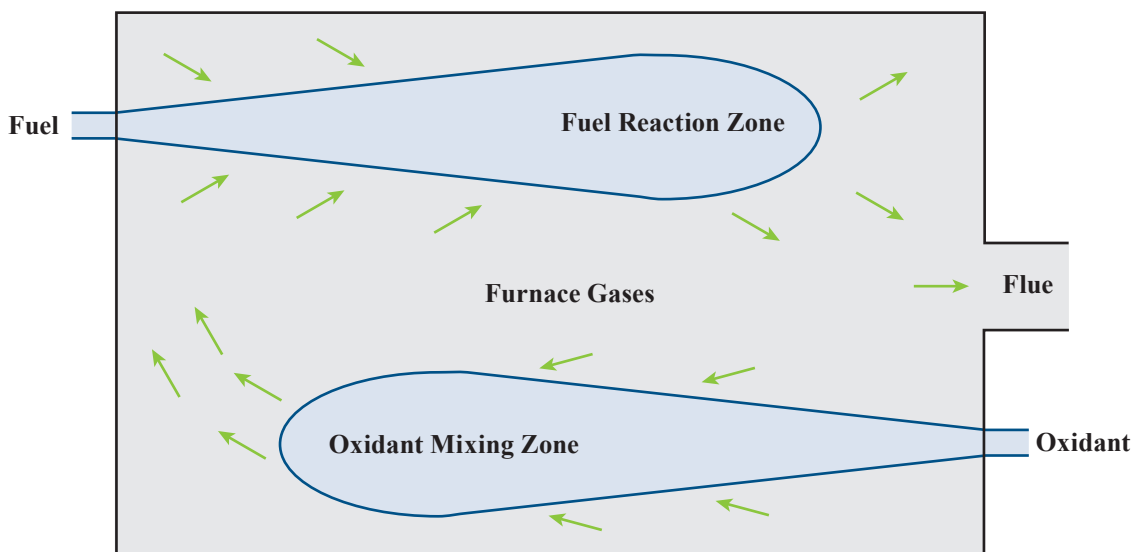
Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.001	0.111

Applications

- ◆ Steel and glass industry
- ◆ Any combustion system

Capabilities

- ◆ Up to 30% increase in furnace capacity.
- ◆ Can be used on continuous or batch reheat furnaces.



Dilute Oxygen Combustion

Dezincing of Steel Scrap Reduces Concerns of Recyclability and Waste Streams

Half of the steel produced in the United States is derived from scrap. With the use of zinc-coated prompt scrap increasing fivefold since 1980, steelmakers are feeling the effect of increased contaminant loads on their operations. The greatest concerns are the cost of treatment before disposal of waste dusts and the water associated with remelting zinc-coated scrap.

With financial assistance from ITP, Argonne National Laboratory with Metal Recovery Technologies, Inc., and Meretec Corporation have developed a technology that separates steel scrap into dezincing steel scrap and metallic zinc. The removal of zinc from steel scrap increases the recyclability of the underlying steel, decreases steelmaking dust, and decreases zinc in wastewater streams.

The process consists of two stages: dissolving the zinc coating from scrap in a hot, caustic solution and recovering the zinc from the solution electrolytically. Through a galvanic process, the zinc is removed from the steel and is in solution as sodium zincate ions rather than zinc dust. The steel is then rinsed with water and ready for reuse. Impurities are removed from the zinc solution, and then a voltage is applied in order to grow metallic zinc via an oxidation-reduction reaction. All waste streams in this process are reused.

Benefits

Pollution Reduction

Removal of zinc decreases steelmaking dust released to the air as well as pollutants in wastewater streams. The process itself does not consume any chemicals, other than drag-out losses, and produces only a small amount of waste.

Productivity

Removing zinc prior to processing of scrap saves time and money in disposal of waste dusts and water. Without the zinc, this high-quality scrap does not require extra handling, blending, or sorting for remelting in steelmaking furnaces.

Overview

- ◆ Developed by Argonne National Laboratory
- ◆ Commercialized in 2003
- ◆ Steel scrap sold to several dealers, steel-makers, and foundries after dezincing

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.030	0.017

Emissions Reductions

(Thousand Tons, 2004)

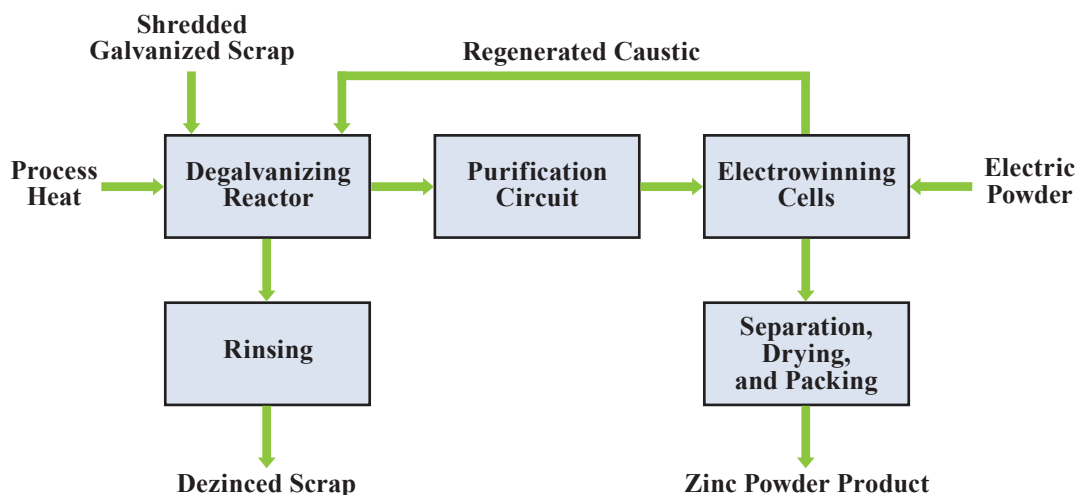
Particulates	SO _x	NO _x	Carbon
0.0	0.010	0.005	0.0462

Applications

Primarily the steel and foundry industries.

Capabilities

- ◆ Improves quality of steel scrap that steelmakers can use.
- ◆ Produces 99.8% pure zinc for resale.



Electrochemical Dezincing of Galvanized Steel Scrap

Laser Contouring System for Refractory Lining Measurements

IMPACTS

Optical Sensor Provides Real-Time Process Control Resulting in Reduced Costs and Improved Performance

A suite of new robust sensors and control systems for base oxygen furnace (BOF) and other steelmaking operations makes possible dynamic process control and rapid assessment of the effectiveness of operations. With ITP support, Sandia National Laboratories and the American Iron and Steel Institute developed the Laser Contouring System (LCS) now being sold by Process Metrix. The LCS rapidly measures refractory lining thickness and incorporates high-speed, laser-based distance measuring equipment with a robust mechanical platform and easy-to-use software. With a laser scan rate of over 8,000 points per second, a single vessel scan can include over 500,000 individual contour measurements, providing incredibly detailed contour resolution and accurate bath height determination.

Contour maps of both vessel wall and bottom clearly illustrate lining thickness over the entire vessel interior. Thickness values are displayed both numerically and by color key, immediately revealing regions that might require attention. The report generator automatically prints all of the views and screens needed by the mill to make informed process decisions. New software releases, that include upgrades and feature requests from customers, are made twice annually.

Two principle objectives are emphasized in the mobile platform design: speed and simplicity. Fast measurement times are achieved using a laser-based navigation system. Working from three reflectors mounted on the building structure behind the cart, this system automatically measures the cart position relative to the BOF and reports position information directly to the LCS computer. The navigation system is completely automatic and updates 8 times per second. Process Metrix has also implemented a radio frequency (RF) link that continuously broadcasts the vessel tilt to a receiver located in the cart. The RF-link incorporates 2.4 GigaHertz spread-spectrum technology for interference-free transmission. During the measurement, the RF receiver automatically reports the vessel tilt to the LCS computer. Together, the laser navigation system and RF link enable fast, error-free measurement of the vessel lining thickness. Single measurements can be made in 20-30 seconds. An entire map of the vessel interior, consisting of 4-6 measurements and 500,000+ data points, can be completed in less than 10 minutes.

Fixed position installation is available for converter and ladle applications. This type of installation coupled with the high measurement speed of the LCS enables measurements after every heat with little or no loss of process time.

Overview

- ◆ Commercialized in 2001 by Process Metrix
- ◆ 4 units in operation at three United States installations in 2004 and additional units in use overseas

Applications

Rapid measurements of vessel wall and bottom lining thickness in the steel furnace or ladle environments

Capabilities

- ◆ Available as a mobile platform or a fixed position installation.
- ◆ Maps the entire vessel interior in less than 10 minutes.
- ◆ Provides detailed contour resolution and vessel lining thickness with over 500,000 individual contour measurements.

Benefits

Energy Savings

Reduces energy usage via rapid real-time measurements and no loss of process time.

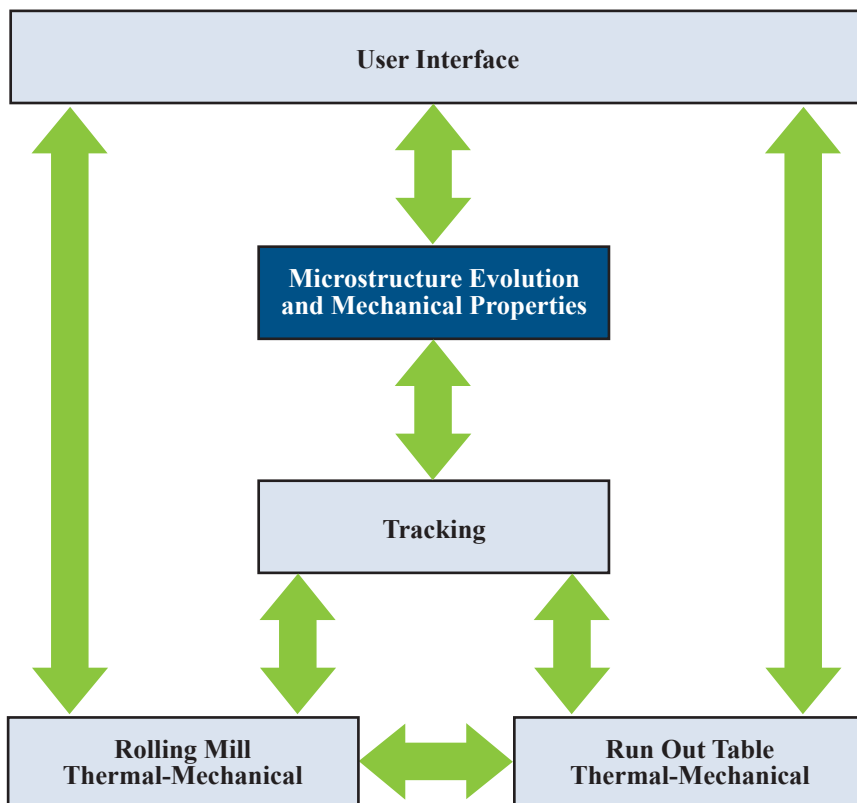
Productivity

Reduces maintenance on BOF refractory via automated furnace inspection.

Innovative Model Provides a More Detailed Insight into Mill Operations to Reduce Costs and Improve Quality

Many hot rolled products must achieve strict strength and toughness requirements making control of the microstructure critical. This causes these products to be difficult to make and requires many costly full production trials before the range of both chemical composition and hot strip mill processing parameters can be defined. The Hot Strip Mill Model (HSMM) is an invaluable tool to cost effectively assist in determining the optimum processing conditions to achieve the desired product properties. This model runs in an off-line mode, thereby saving many tons of wasted product that might be scrapped in trying to identify the proper mill set-up.

The HSMM also provides additional savings in grade consolidation, control optimization of new grades, and improvement of mechanical and microstructure properties for downstream processing. The model can consolidate grades by allowing the user to develop different processing setups for the same steel grade that will then achieve the various mechanical properties needed for the different finished products. The HSMM can improve on-line control optimization for new grades by using what is learned from the HSMM to help setup the on-line models so they learn faster how to optimize the processing of the new grade. And finally, processing the steel to achieve the optimum or specific microstructure attributes further improves processing of the product in downstream operations.



Components of the HSMM

Overview

- ◆ Developed by The American Iron and Steel Institute as part of its Advanced Process Control Program and being marketed by INTEG Process Group, Inc.
- ◆ Being used by US Steel, Weirton Steel, IPSCO Steel, Nucor Steel, Saldanha Steel (ISCOR Steel South Africa), Lloyds Steel (India), St. Petersburg Technical University (Russia) and Algoma Steel (Canada).

Applications

The HSMM is applicable to any hot rolling mill that produces sheet or plate products (flat rolled material). The model can handle a variety of rolling mill configurations, including roughing mills, coil boxes, finishing mills, run out tables, and coilers.

Capabilities

- ◆ Allows the user to easily modify the mill configuration or processing parameters to see its impact on the end results of the product being rolled (simulated).
- ◆ Can also be used as a training tool, allowing operators to see the end result for different processing conditions or grades of steel.

Benefits

Competitiveness

Improves industrial competitiveness through product optimization and cost savings.

Productivity

Decreases product variability through the development of a predictive tool, which can quantitatively link the properties of hot rolled product to the operating parameters of the hot strip mills.

Recovery of Acids and Metal Salts from Pickling Liquors

IMPACTS

Acid and Salt Recovery Now Cost-Effective for Smaller Manufacturers

Steel fabrication processes often use pickling (immersing steel in acid) to remove oxide layers from recently heated steel. Technology for recycling the sulfuric acid has been available for large installations for some time. The Green Technology Group, in collaboration with DOE's Inventions and Innovation Program, developed the Pickliq® process to make sulfuric acid recovery cost-effective for smaller facilities.

The Pickliq process combines diffusion dialysis, energy transfer, and low-temperature crystallization technologies to efficiently recover acids and metal salts. It has demonstrated significant gains in production capacity, quality control, and productivity by maintaining pickling tank acid and iron concentrations at preset levels. Bath uniformity and predictable performance raises output and minimizes rejects and rework. To manufacturers, these benefits are even more important than the simple cost savings from eliminating waste. Additional benefits include reduced demand for virgin acids and elimination of chemicals to neutralize waste acid, as well as energy and cost savings associated with acid transportation and disposal.

The Green Technology Group has recently improved the technology, and the new system called Pickliq Hydrochloric Acid Regeneration (PHAR®) will soon be commercially available.

Benefits

Productivity

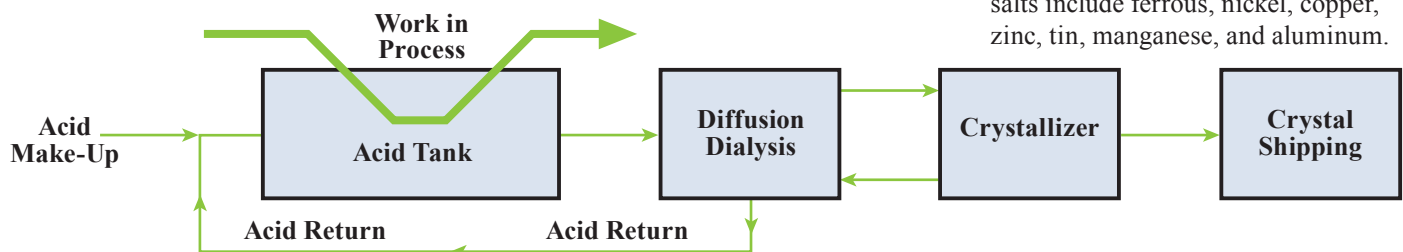
Significantly improves process uniformity and product quality, reduces downtime associated with acid revitalization, improves overall process effectiveness and throughput, and reduces rework. Optimal pickling bath acid concentrations are continuously maintained.

Profitability

Costs less than transporting and disposing of waste acid. Eliminates long-term liabilities of waste disposal. Generates a saleable by-product (metal salts) that can be used in a variety of applications. Results in rapid payback estimated at 6 months to 2 years.

Waste Reduction

Recycles acid for reuse, eliminating disposal of spent acid and neutralized sludge. Reduces the demand for virgin acids, conserving petroleum feedstock.



Recovery of Acids and Metal Salts from Pickling Liquors

Overview

- ◆ Developed by Green Technology Group
- ◆ First commercial unit installed in 1995
- ◆ 2 units operating in the United States

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.011	0.001

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.0	0.026

Applications

To be used primarily in the primary metal industry but could be used in the metal finishing and circuit board industries for recovering acids and metal salts from etching and metal stripping

Capabilities

- ◆ Provides better process control and product quality.
- ◆ Maintains acid baths at optimum concentration.
- ◆ Permits continuous operation.
- ◆ Can recover hydrochloric, sulfuric, nitric, hydrofluoric, and other acids (including nonmineral acids).
- ◆ Recovers metal salts into a saleable by-product. Metals with recoverable salts include ferrous, nickel, copper, zinc, tin, manganese, and aluminum.

Shorter Spheroidizing Annealing Time for Tube/Pipe Manufacturing

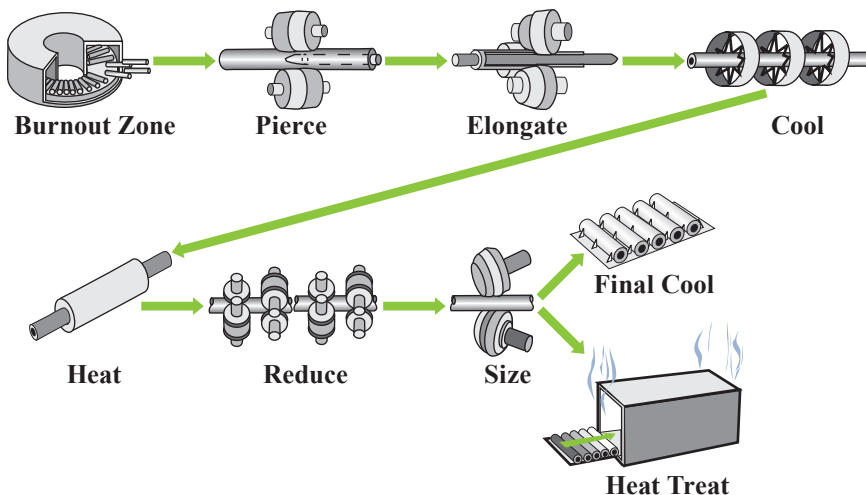
IMPACTS

New Process Results in Productivity Improvements and Energy Savings

The steel industry is working to improve the manufacturing of tubes and pipes while maintaining key steel parameters and reducing the amount of energy used in the process. The Timken Company developed an enhanced spheroidized annealing cycle for through-hardened steel. This technology is a by-product of a larger ITP sponsored project, the “Controlled Thermo-Mechanical Processing (CTMP) of Tubes and Pipes for Enhanced Manufacturing and Performance.”

The spheroidized annealing process changes the hard, elongated carbide particles in the steel to be spherical in shape with a preferred diameter. The size and shape of the original elongated carbides produced by the previous hotworking process influence the ability to spheroidize the carbides. The spheroidized annealing process consists of heating the carbide particles to temperatures at which they form spherical shapes. This entire heating and holding cycle takes 20 to 50 hours. Various combinations of temperatures and times can be used to achieve the desired shape and distribution of the carbide spheres. In this ITP sponsored project, experimentation was conducted to characterize the effect of the original elongated carbides and the annealing times and temperatures on the resulting spheroid size and distribution.

The experimental results helped The Timken Company shorten the annealing cycle time by 20% and condense the number of plant trials to achieve that. The result was an optimized cycle that reduced energy consumption and improved productivity while generating a quality product with the desirable metallurgical properties for forming and machining.



Tube Making Process

Overview

- ◆ Developed by The Timken Company
- ◆ Process being used at two facilities in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.084	0.017

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.002	0.266

Applications

- ◆ Steel tube and pipe manufacturers
- ◆ Specialty metal manufacturers

Capabilities

Shortens annealing cycles and saves energy.

Benefits

Energy Savings

Reduces fuel requirements by reducing annealing cycle time by 20%.

Productivity

Increases productivity approximately 10% due to the reduced cycle time.

Product Quality

Provides the end user with steel that is easily formed and machined with the same desirable metallurgical properties.

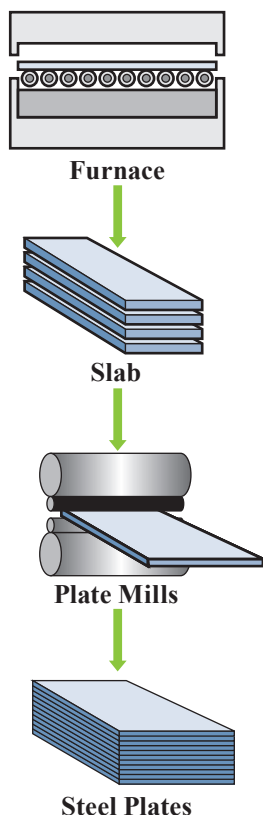
Steel Reheating for Further Processing

IMPACTS

New Oxy-Fuel Burners Reduce Energy Use While Reducing Emissions and Increasing Productivity

Steel reheating is an energy-intensive process. Historically, “recuperators” have been used to preheat combustion air, thereby conserving energy. Innovations that are more recent include oxygen enrichment and the use of regenerative burners, which provide higher preheat air temperatures than recuperators. These processes increase NO_x emissions with increased air preheat temperature, unless special equipment is used. NO_x is an industrial pollutant whose emissions are being increasingly restricted.

With assistance from a NICE³ grant, Praxair developed and demonstrated a low NO_x, oxygen-burner retrofit using 100% oxygen. The burners require less fuel to heat steel and promote lower overall heat content in the waste gases. Energy use was reduced by 60% from five to two million Btu per ton of steel processed. Air burners can be retrofitted or new burners can be installed where the fuel and oxygen are injected through separate ports rather than through a single burner. The low NO_x feature of this system is expected to be a general requirement of the steel industry of the future. The Praxair technology provides exceptionally uniform heating of the steel. This results in better rolling-mill performance and allows a reheat furnace to economically operate at higher production rates. Successful implementation of this technology eliminates the need to periodically replace recuperators and install NO_x removal equipment.



Production of Steel Plates Using Reheat Furnace

Overview

- ◆ Burners are available from Praxair, Inc.
- ◆ 4 burners retrofitted on No. 6 furnace at ISG/Bethlehem Steel's Burns Harbor Plant

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
1.00	0.154

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.018	2.44

Applications

- ◆ Steel reheating furnaces
- ◆ Burners can be retrofitted or added to new furnaces

Capabilities

- ◆ Reduces NO_x and particulate emissions from steel furnaces.
- ◆ Results in energy savings per ton of steel while increasing the quality of the metal.

Benefits

Emissions Reductions

Reduces NO_x emissions and particulates by 60 to 90% per ton of steel.

Productivity

Provides uniform heating of steel, resulting in better mill performance and an increase in productivity of 3%.

Profitability

Eliminates the need for recuperators and NO_x removal equipment.

New Nickel Aluminum Transfer Rolls for High-Temperature Applications

A nickel aluminum alloy developed by Oak Ridge National Laboratory (ORNL), in conjunction with ITP, has transformed the steel heat-treating resists industry. Nickel aluminide is a strong, hard, inter-metallic material that resists wear, deformation, and fatigue from repeated stress or high temperatures. Because it becomes stronger and harder at high temperatures, nickel aluminide transfer rolls are well suited to replace steel transfer rolls in heat-treat roller hearth furnaces.

In the annealing furnace at Bethlehem Steel Burns Harbor Plate Division (now ISG Burns Harbor Plate Inc.), nickel aluminide inter-metallic alloy rolls provide greater high-temperature strength and wear resistance compared with the conventional H series cast austenitic alloys currently used in the industry. ORNL and Bethlehem (ISG) partnered under the U.S. Department of Energy's ITP Emerging Technology Deployment Program to demonstrate and evaluate the nickel aluminide inter-metallic alloy rolls as part of an updated, energy-efficient, large, commercial annealing furnace system.

The project involved developing welding procedures for joining nickel aluminide inter-metallic alloys with H-series austenitic alloys and developing commercial cast roll manufacturing specifications. Several commercial suppliers helped produce a quantity of high quality, reproducible nickel aluminide rolls for a large steel industrial annealing furnace. The capability of the rolls in this furnace were then demonstrated and trials were performed to evaluate the benefits of new equipment and processes.

Straight-through plate processing is now possible because of the nickel aluminide rolls, which also improved the quality of the plate product surface to allow the additional processing of surface critical material. Benefits also include associated large reductions in maintenance, reduction in spare rolls and associated component costs, and potential for greater throughput and productivity. Estimated project fuel cost reductions alone for processing 100,000 tons/yr through this furnace are \$100,000/yr from straight through processing assuming natural gas prices of \$6.00/MMBtu. The nickel aluminide rolls are competitively priced with conventional H series alloy rolls.

Benefits

Productivity

Increased roll life reduces furnace shutdowns to replace worn components, resulting in increased production. Maintenance and furnace shutdowns decreased from weekly to quarterly. Reduced damage to steel during heat-treating, resulting in less steel scrap.

Product Quality

The new rolls are two to three times stronger than conventional steel roll assemblies. The strength increases at temperatures greater than 1475°F. The high aluminum content resists oxidation and carburization at high temperatures without adhering to steel.

Profitability

Extends transfer roll life three to five times and reduces life cycle costs by 75% compared with steel rolls. Produces steel plates with greater, more consistent quality.

Overview

- ◆ Nickel aluminide developed by Oak Ridge National Laboratory
- ◆ Being marketed by Duraloy Technologies, Inc.
- ◆ Nickel aluminide transfer rolls technology commercialized in 1993

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.033	0.017

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.002	0.265

Applications

Heat-treat roller hearth furnaces to move high-temperature steel plates through the heat treatment process

Capabilities

Can operate in temperatures as high as 2100°F.

IMPACTS

◆ Callidus Ultra-Blue (<i>CUB</i>) Burner	68
◆ Catalytic Combustion	69
◆ Chemical Vapor Deposition Optimization of Ceramic Matrix Composites	70
◆ Energy-Conserving Tool for Combustion-Dependent Industries	71
◆ Evaporator Fan Controller for Medium-Temperature Walk-In Refrigerators	72
◆ Fiber-Optic Sensor for Industrial Process Measurement and Control	73
◆ Fiber Sizing Sensor and Controller	74
◆ Foamed Recyclables	75
◆ Forced Internal Recirculation Burner	76
◆ Freight Wing™ Aerodynamic Fairings	77
◆ High-Temperature Radiant Burner	78
◆ Improved Diesel Engines	79
◆ Infrared Polymer Boot Heater	80
◆ In-Situ, Real Time Measurement of Melt Constituents	81
◆ Materials and Process Design for High-Temperature Carburizing	82
◆ Method of Constructing Insulated Foam Homes	83
◆ Mobile Zone Optimized Control System for Ultra-Efficient Surface-Coating Operations	84
◆ Nickel Aluminide Trays and Fixtures Used in Carburizing Heat Treating Furnaces	85
◆ PowerGuard® Photovoltaic Roofing System	86
◆ Process Particle Counter	87
◆ Radiation-Stabilized Burner	88
◆ Real-Time Neural Networks for Utility Boilers	89
◆ RR-1 Insulating Screw Cap	90
◆ Solid-State Sensors for Monitoring Hydrogen	91
◆ SpyroCor™ Radiant Tube Heater Inserts	92
◆ SuperDrive – A Hydrostatic Continuously Variable Transmission (<i>CVT</i>)	93
◆ Thin Wall Casting of Stainless Steel	94
◆ Ultra-Low NO _x Premixed Industrial Burner	95
◆ Uniform Droplet Process for Production of Alloy Spheres	96
◆ Uniformly Drying Materials Using Microwave Energy	97
◆ Variable-Frequency Microwave Furnace	98
◆ Waste Fluid Heat Recovery System	99
◆ Waste-Minimizing Plating Barrel	100

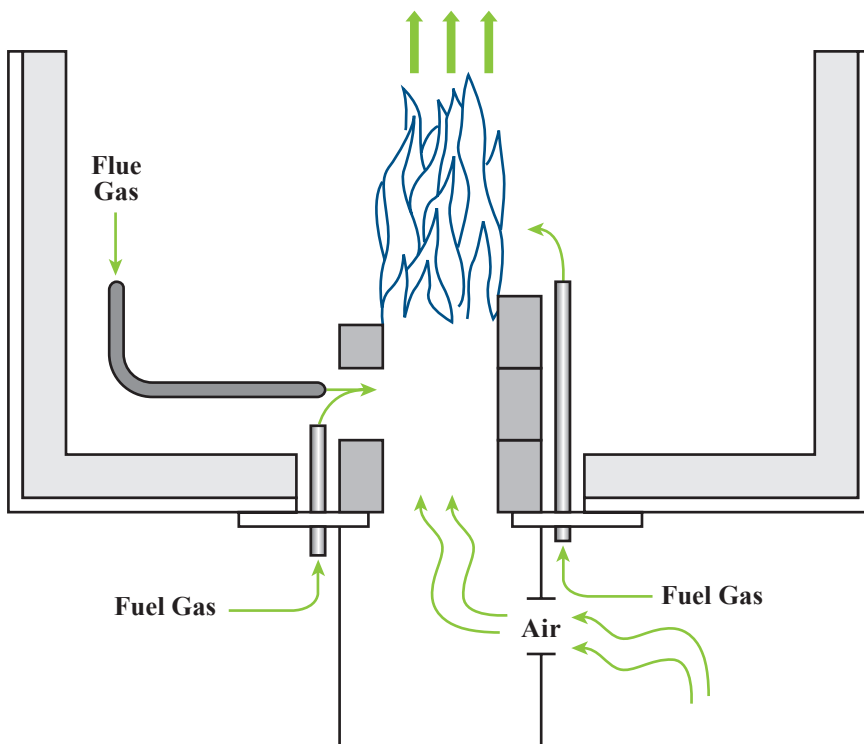
Callidus Ultra-Blue (CUB) Burner

IMPACTS

A New Generation of Smart, Integrated Burner/Fired-Heater Systems

The refining and chemicals industries rely on process heaters to heat liquids and induce chemical reactions during production processing. Process heaters in these two industries generate over 235,000 tons of NO_x emissions annually. The chemicals and refining industries are facing more stringent environmental regulations to reduce NO_x emissions; for example, the state of Texas has ordered refiners in the Houston area to reduce NO_x emissions by 80+%.

Callidus Technologies, along with funds and resources from ITP, Gas Research Institute (GRI), and Arthur D. Little Company, developed and demonstrated an ultra-low NO_x emissions burner. The burner uses internal flue gas recirculation to reduce 80% of the NO_x emissions, with many applications achieving reductions greater than 90%. Callidus Technologies, with licensing rights from GRI, is manufacturing and marketing the Callidus Ultra-Blue Burner to the chemicals and refining industries where potential NO_x reductions of 200,000 tons/year are possible.



Callidus Ultra-Blue Burner

Overview

- ◆ Developed by Callidus Technologies, Inc.
- ◆ Commercialized in 2000
- ◆ Over 2200 burner units installed by 2004

Applications

High-temperature ultra-low NO_x burner for the chemicals, petrochemicals, and refining industries

Capabilities

The Callidus burner works with

- ◆ Natural or forced-draft operation
- ◆ Refinery fuel gas, natural gas, and high and low hydrogen content
- ◆ Ambient and preheated air.

Benefits

Emissions Reductions

Reduces thermal NO_x in the combustion zone by 80% to 90%.

Profitability

Eliminates or reduces the need for expensive post-combustion emission-altering equipment.

Other

Is designed to be user-friendly.

IMPACTS

Advanced Catalytic Combustion System Reduces NO_x Emissions

Natural-gas-fired turbine systems currently require complex after-treatment systems to clean the exhaust of harmful emissions. Many of these emissions could be reduced by lower operating temperatures during the combustion process.

With the support and recognition from many organizations, including DOE, the California Air Resources Board, the California Energy Commission, and the U.S. Environmental Protection Agency, Catalytica Energy Systems, Inc., has developed an innovative system to reduce turbine emissions. The Xonon Cool Combustion® System uses a catalytic process instead of a flame to combust the fuel, thereby lowering the combustion temperature and significantly reducing the formation of NO_x.

While maintaining turbine efficiency, the technology has the potential to reduce the cost associated with achieving ultra-low emissions while generating electricity with gas turbines. With the growing need for electricity generation that produces less pollution, Catalytica Energy Systems' solution provides a cost-effective method to meet air pollution control standards through pollution prevention rather than cleanup.

Benefits

Emission Reductions

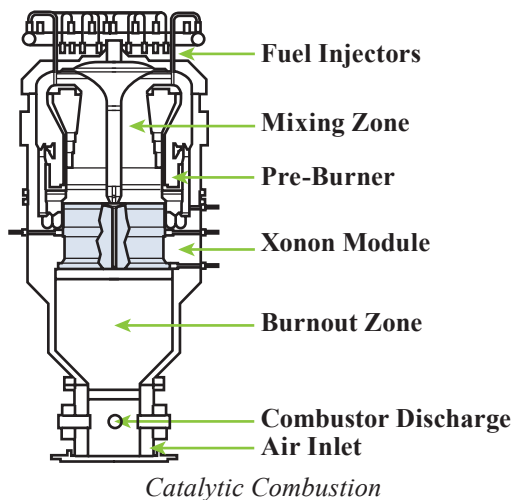
The system reduces air pollutant emissions from gas turbine energy generation systems. In its first commercial installation, the NO_x output was reduced from approximately 20 ppm to well below 3 ppm.

Pollution Reduction

The catalytic system avoids the need for costly or burdensome exhaust cleanup systems that use toxic reagents such as ammonia.

Productivity

The NO_x reduction process using catalytic combustion does not reduce the turbine efficiency. The system has demonstrated operating reliability greater than 98%.



Overview

- ◆ Developed by Catalytica Energy Systems, Inc.
- ◆ Has accumulated over 18,000 hours of operation on the grid in field demonstrations
- ◆ First commercialized in 2002

Applications

- ◆ Commercially available through Kawasaki Gas Turbines-America on its M1A-13X, a 1.4-MW gas turbine as part of the GPB 15X cogeneration system
- ◆ For power generation turbine systems with low emission requirements or preferences, such as California installations, international systems, and systems with low pollution requirements
- ◆ Could also be applied to turbine generation systems with cogeneration to improve energy efficiency
- ◆ Being actively developed in partnership with GE Power Systems for its GE10, a 10-MW gas turbine, and with Solar Turbines for its Taurus 70, a 7.5-MW gas turbine

Capabilities

- ◆ Can be used in a broad range of turbine sizes and will not reduce the turbine efficiency.
- ◆ Achieves emissions less than 3 ppm for NO_x and less than 10 ppm for CO.
- ◆ Uses a catalyst rather than a flame to combust fuel.

Chemical Vapor Deposition Optimization of Ceramic Matrix Composites

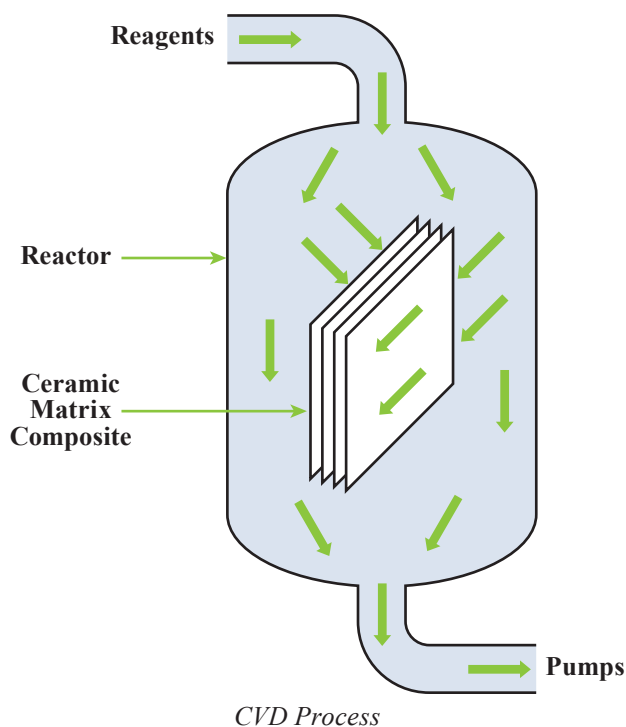
IMPACTS

Chemical Vapor Deposition Optimizes Industrial and Aerospace Ceramic Matrix Composites

Ceramic matrix composites comprise a new technology that is practical for a wide range of industrial and aerospace applications. Ceramic matrix composites are extremely heat-tolerant and corrosion-resistant, making them ideal for applications requiring lightweight materials capable of withstanding high temperatures.

Chemical vapor deposition (CVD) is used to enhance the physical characteristics of the ceramic matrix composites. Honeywell Advanced Composites, Inc. uses CVD to apply a thin, even interface coating to the surface of ceramic fibers. A coating of silicon carbide is then added to further strengthen the composite, making it stronger than conventional composites and shatterproof upon failure.

Sandia National Laboratory partnered with AlliedSignal Composites, a major producer of high-tech ceramic composites, to optimize the CVD process presently used by Honeywell Advanced Composites. Researchers used a Sandia research reactor, originally funded by ITP, to determine identities and amounts of gaseous-phase species present during CVD. Sandia researchers developed a computer model whose predictions are now being used to increase the throughput of two Honeywell coating reactors. The partnership saved Honeywell approximately \$1 million in development time and expenses.



Overview

- ◆ Developed by Sandia National Laboratory in cooperation with Honeywell Advanced Composites, Inc., formerly AlliedSignal Composites, Inc.
- ◆ Commercialized in 1997
- ◆ 2 CVD reactors presently use the optimized coating process to make ceramic matrix composites

Applications

- ◆ Liners in jet engines
- ◆ Leading edges of jet turbine engine vanes
- ◆ Liquid oxygen thrusters in rockets
- ◆ Components for the reusable launch vehicle for space shuttles

Capabilities

- ◆ CVD ceramic composites can replace superalloys in numerous aerospace and industry applications.
- ◆ Can withstand high-temperature, corrosive environments better than traditional superalloys.

Benefits

Energy Savings

In turbine engines, CVD ceramic composites allow higher operating temperatures that produce greater fuel efficiency.

Productivity

Computer software operates CVD reactors at optimal conditions and reduces the time to process CVD ceramic composites. Reduces the number of reactor operations. Increases the number of parts processed per operation, resulting in greater productivity.

Product Quality

CVD ceramic composites weigh about one-third less than superalloy counterparts, have greater strength and toughness than conventional alloys, and will not shatter when failed.

DOE Industrial Technologies Program

Energy-Conserving Tool for Combustion-Dependent Industries

IMPACTS

MultiGas™ Analyzer Provides On-Line Feedback Resulting in Lower Energy Use and Emissions

Using a NICE³ grant, Advanced Fuel Research (AFR), Inc., has developed and demonstrated a new system to improve continuous emissions monitoring (CEM) and on-line process tuning of combustion-dependent systems such as boilers and turbines.

Many existing combustion-monitoring techniques are unable to effectively and efficiently monitor all combustion gases, including difficult-to-separate hydrocarbons such as formaldehyde and emission control reactants such as ammonia. Typical CEM systems monitor a limited number of gases using an expensive collection of single-gas analyzers. These systems require a temperature-controlled room and a substantial ongoing investment to maintain operation and calibration of the facility.

The new multi-gas analyzer technology is portable, low-cost, and energy-efficient and combines advanced Fourier transform infrared spectroscopy with advanced electronics and software. This system provides CEM and on-line feedback for operational tuning of combustion-based industrial processes. The system allows for real-time measurement of criteria emissions and pollutants, including pollutants that are not usually monitored such as formaldehyde and ammonia. The improvements in dependability and efficiency and the lack of need for expansive temperature-controlled space result in lower operations, energy, and labor costs.

Benefits

Environmental

Measures criteria and hazardous air pollutants that are not typically monitored on-site in real-time, such as formaldehyde and ammonia.

Productivity

Reduces maintenance and performance verification time, resulting in labor savings of up to 80%.

Overview

- ◆ Developed by Advanced Fuel Research, Inc.
- ◆ Commercialized in 2001
- ◆ Manufactured and sold by MKS Instruments
- ◆ 20 units operating in the United States in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.004	0.002

Emissions Reductions

(Thousand Tons, 2004)

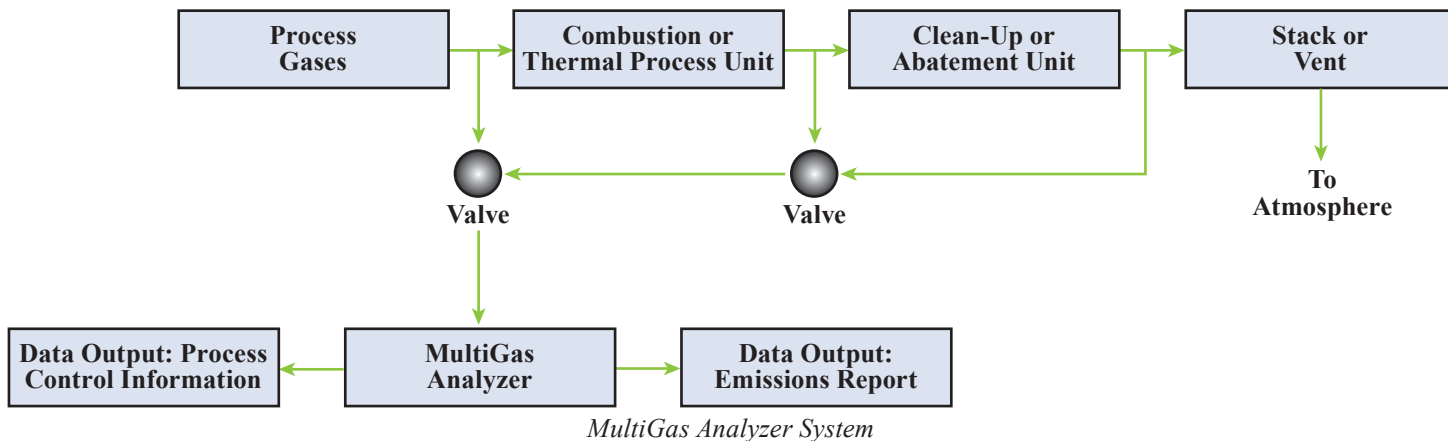
Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.0	0.031

Applications

Systems and processes requiring combustion of fuels in engines, boilers, incinerators, and turbines

Capabilities

- ◆ Achieves higher combustion efficiencies through closely monitored and controlled combustion.
- ◆ Reduces emissions through verified efficient operation.



Evaporator Fan Controller for Medium-Temperature Walk-In Refrigerators

IMPACTS

Fan Controller Saves Energy in Two Ways

With assistance from DOE's Inventions and Innovation Program, Advanced Refrigeration Technologies (ART) commercialized an innovative control strategy for walk-in refrigeration systems. The ART Evaporator Fan Controller is inexpensive and easy to install.

The concept and operation of the ART controller is technically quite simple: refrigerant flow is sensed by temperature differential at the expansion valve within the evaporator. When refrigerant is not flowing through the evaporator/evaporators, voltage is dropped to the evaporator fans, saving energy in two ways. First and foremost, the evaporator fans consume less energy. Secondly, heat introduced to the refrigerated chamber from the evaporator fan motors is decreased. This decrease in heat, coupled with a decrease in thermal inversion, results in a decreased overall box load, thereby reducing the compressor/condenser on-duty cycle. The slow fan speed maintains air circulation to avoid temperature stratification. The lower air speed also maintains natural product moisture, thereby increasing shelf life.

Benefits

Energy Savings

Reduces evaporator and compressor energy consumption by 30% to 50%.

Productivity

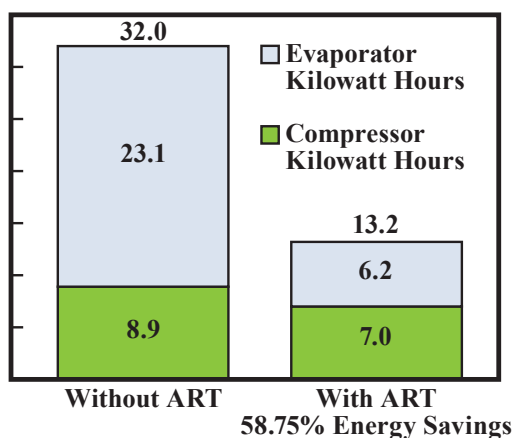
Even temperature distribution and lower air velocity improve working conditions and result in workers keeping refrigerated spaces closed.

Product Quality

Less air movement maintains the natural moisture in open product, so freshness and shelf life is increased without affecting overall relative humidity within the refrigerated chamber.

Profitability

Lower running times increase equipment life span and cut maintenance and replacement costs.



Average Daily Energy Consumption for a 29,200 Btu Evaporator

Overview

- ◆ Developed by Advanced Refrigeration Technologies, Inc.
- ◆ Commercialized in 1997
- ◆ Being sold by RS Services
- ◆ Over 1425 units operating in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.054	0.016

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.003	0.003	0.309

Applications

Decrease in energy consumption in low- and medium-temperature walk-in refrigeration and freezer systems in restaurants, cafeterias, mess halls; grocery and convenience stores; hospitals; colleges and other educational facilities; naval vessels; and custom industrial and commercial applications

Capabilities

- ◆ Control logic cuts evaporator and compressor energy consumption and lengthens component life.
- ◆ Controller can be retrofitted into existing refrigeration systems or incorporated into the design of new equipment.
- ◆ New models have the capability to monitor energy use and savings associated with the ART controller. Monitored information may be downloaded to a PC.

Fiber-Optic Sensor for Industrial Process Measurement and Control

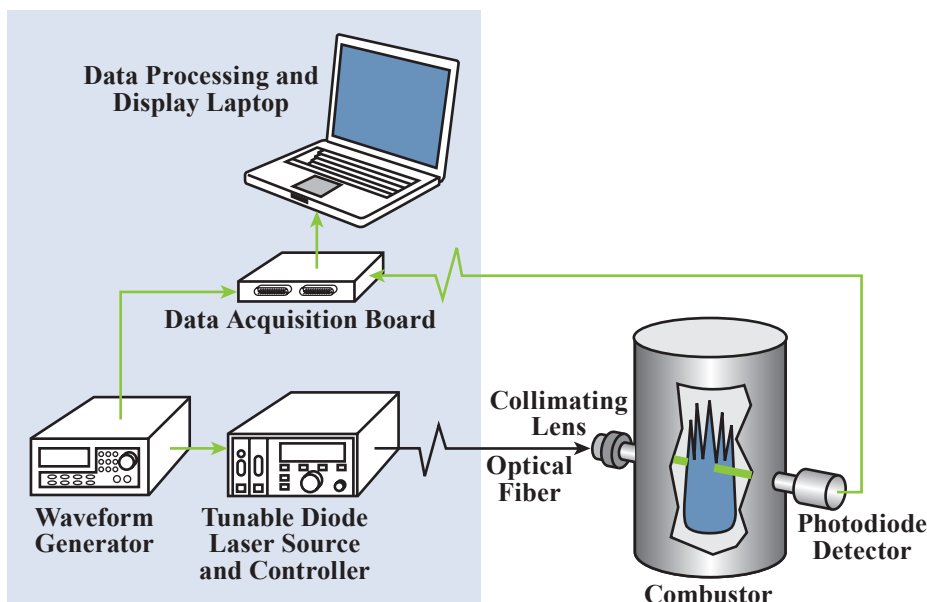
IMPACTS

Reliable Advanced Laser Sensor Helps Control High Temperature Gas Combustion

Through a marketing agreement with MetroLaser, Inc., Bergmans Mechatronics LLC is offering the LTS-100 sensor to the aerospace and industrial markets. This new sensor will help reduce the cost and improve the performance of traditionally difficult temperature measurements.

Many existing industrial process sensors have limited accuracy in applications involving highly corrosive gases at elevated temperature and pressure because they require extractive sampling systems that introduce variations in the temperature, pressure, and composition of the probed gases. Moreover, sampling systems introduce a lag resulting in >1-10 second response times, require frequent servicing, and may be subject to unexpected failures because of their complexity. Using advanced tunable diode laser absorption spectroscopy (TDLAS) sensors for closed-loop process control affords a direct, quantitative measure of the species concentration in the probed region. In addition, by monitoring two or more transitions, the temperature along the optical path can also be determined.

Near-infrared diode lasers are attractive light sources for sensing applications because they are rapidly tunable, small and lightweight, low-cost, efficient, and robust. They operate at near-ambient temperatures and produce narrow bandwidth radiation over a broad wavelength range. These on-line sensors can be combined with process optimization control strategies to significantly improve plant throughput, increase product quality, and reduce energy consumption and waste.



LTS-100 Processing Unit

Overview

- ◆ Developed by MetroLaser Inc., Irvine, CA
- ◆ Commercialized in 2003
- ◆ Being provided as a service in the United States by MetroLaser

Applications

- ◆ Coal-fired power plants to achieve accurate real-time temperature measurements
- ◆ Solid propellant combustion to enhance the capabilities of the next generation of solid-fuel vehicles

Capabilities

Monitors high-temperature gas combustion in process control applications.

Benefits

Reliability

Performs measurements regardless of vibration, flame luminosity, temperature, pressure extremes, and particle interferences.

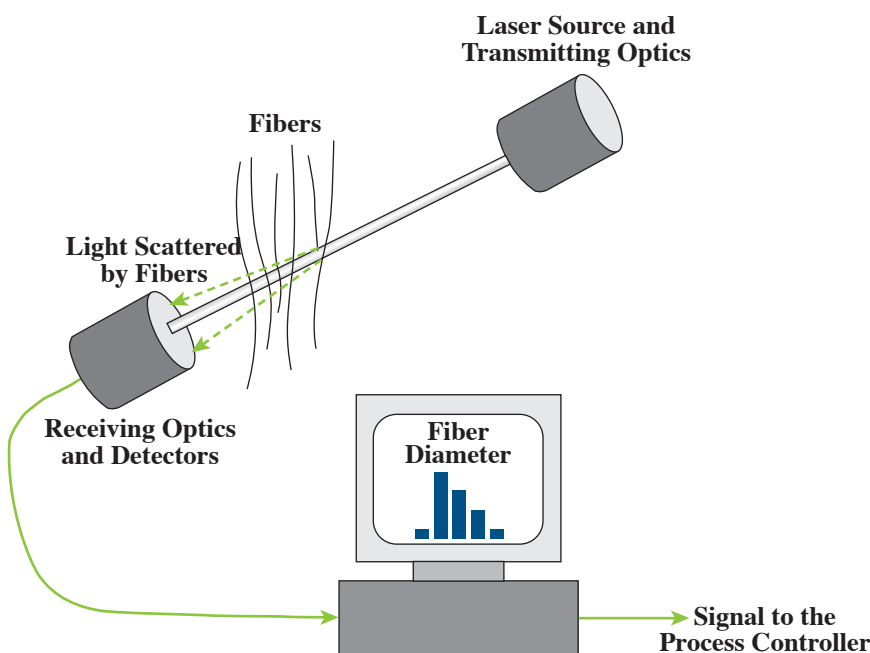
Profitability

Reduces maintenance costs and minimizes slag buildup heat-transfer losses in coal-fired power plants by precisely controlling furnace temperature and startups.

Revolutionary Optical Technology Provides On-Line and Off-Line Measurement of Fiber Sizes

Fiber size (or denier) has a significant effect on the performance of fiber-based products, such as filters, insulation, and composites. Fiber samples are generally characterized by optical or electron microscopy. Flow resistance of a sample of fibers (e.g., by the Micronaire™ technique) is also used to estimate the mean fiber size. However, these methods require sampling and are time consuming, and microscopic measurements are usually based on a small number of fibers selected from an image of a collection of fibers and may not be statistically reliable. Rapid measurement of fiber size, based on a large sample, is desirable for quality control of fiber-based products, development of new fiberizing processes, and basic research on fiber generation. With assistance from DOE's Inventions and Innovation Program, Powerscope, Inc., developed FibrSizr™ which provides such rapid measurements for both on-line and off-line fiber characterization. The sample size is large and usually consists of hundreds of fibers.

FibrSizr consists of a new laser instrument developed for the accurate real-time and in-situ determination of fiber diameter distributions. This device can be used to monitor nonwovens and glass fibers during production and to rapidly measure fiber size distribution in a web sample. This technique is applicable across a wide range of polymers, production methods, and fiber sizes.



Fiber Sizing Sensor/Controller Using Ensemble Laser Diffraction

Overview

- ◆ Developed and commercialized by Powerscope, Inc., in 2004
- ◆ Sale, lease arrangements, and contract measurements completed for several major fiber manufacturers in the United States

Applications

Can be used in off-line and on-line process control of fibers on a variety of production/treatment methods such as meltblown, spunbond, meltspun, carded, chemical bonded, needlepunched, spunlaced, stitchbonded, thermal bonded, and rotary fiberizing

Capabilities

- ◆ Offers a new model that uses violet laser, instead of red laser, for better resolution of fine fibers as small as 0.7 micron in mean size.
- ◆ Provides a detachable transmitter and receiver for applications with limited physical access.
- ◆ Covers a wide range of fiber sizes (denier) and fiber densities using adjustable laser power and detector gain.

Benefits

Energy Savings

Eliminates events, such as sudden shutdowns, which result in waste of energy and material by close monitoring of the process.

Pollution Reduction

Minimizes release of pollutants such as CO₂ from the pertinent combustion processes by operating the fiberizers at near optimal conditions.

Product Quality

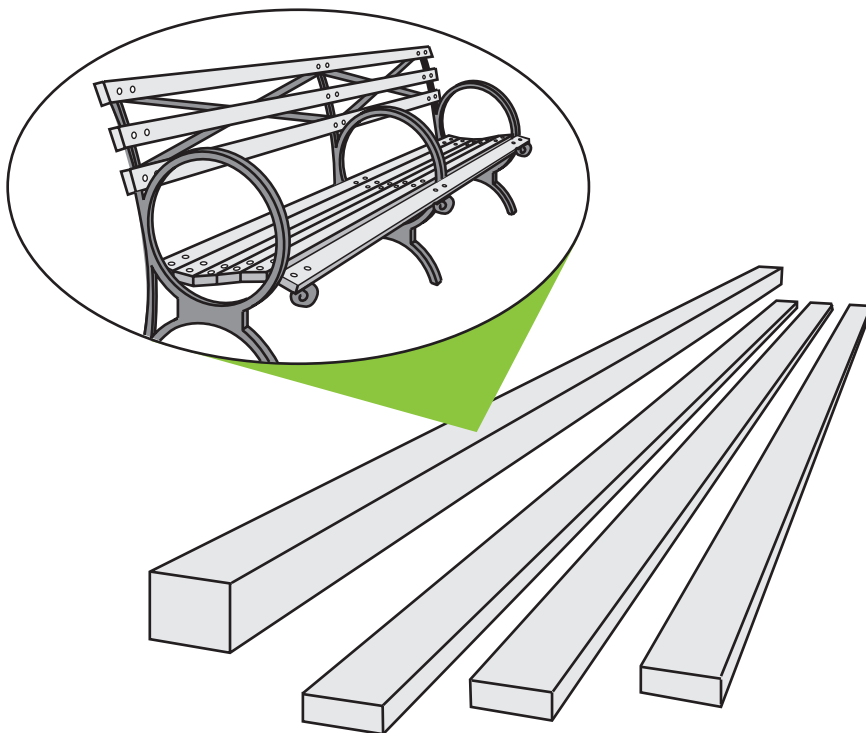
Measures and controls fiber size distribution, which is a critical element in producing nearly all value-added fiber products.

IMPACTS

New Process Allows Coal Ash to be Made into Building Material Products

With a grant from DOE's Inventions and Innovation Program, Century-Board USA, a licensee of Ecomat, Inc., has a fully developed process to convert solid wastes into synthetic building materials.

The process consists of mixing up to 85% solid waste into a modified polyester polyurethane resin with special additives. This polymer system is a thick liquid that is poured into discrete molds or continuously cast, as is done with the 'plastic' lumber. This thick liquid then forms and fills all the crevices of the mold and produces a lightweight, hard, and tough product. The material does not contain thermoplastics such as polyethylene or PVC, wood or sawdust unless requested by the customer.



Foamed Recyclable Building Material

Overview

- ◆ Developed by Century-Board USA
- ◆ One plant operating in the United States with the capacity to process 1 ton/hr of coal fly ash to make plastic lumber
- ◆ 1 pilot plant is making synthetic structural lumber using coal fly ash as the main ingredient

Applications

Among the products made with the Century-Board process are roof tiles, artificial slate, siding, molding, doors, utility poles, marine and dimensional lumber, picture frames, office partitions, and wallboard.

Capabilities

Even though Century-Board will focus on the fly ash-based lumber, the following have been successfully tested in their process as the major ingredients: waste glass, sand, ashes from wood and municipal waste burning, wood flour, waste from metal smeltings, red mud from aluminum refining, mixed recycled plastics, coral dust, rice hulls and rice hull ash, agricultural plant ashes, waste cotton and polyester fibers, paper processing wastes, heavy metal contaminated waste, contaminated soil, foundry sand, sewage sludge, slate dust, and rubber tires.

Benefits

Productivity and Profitability

Below the cost of many competitive materials and can be reground and reused in the same process. It is lightweight and can be 1/10th the density of concrete.

Product Quality

Their synthetic building material products are maintenance-free, fire and weather resistant, lightweight and tough.

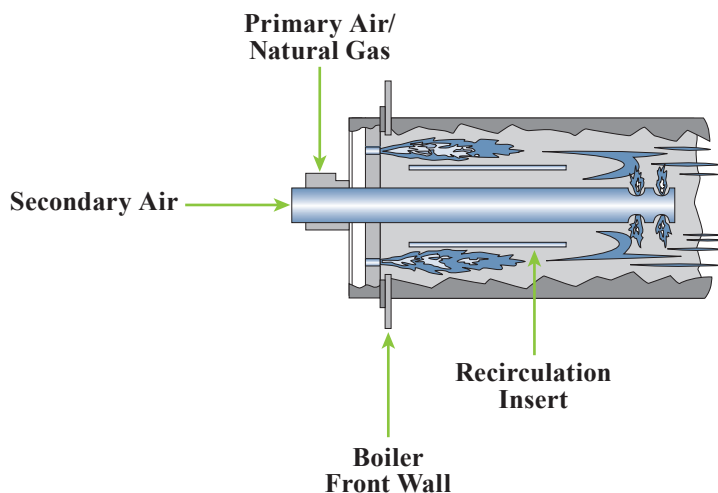
Waste Reduction

Reduces landfilling of coal ashes from utility power plants.

New Burner Significantly Reduces Emissions Compared with Conventional Technology

The forced internal recirculation (FIR) burner combines several techniques to dramatically reduce NO_x and CO emissions from natural gas combustion without sacrificing boiler efficiency. One technique is premixed substoichiometric combustion and significant internal recirculation of partial combustion products in the first stage to achieve stable, uniform combustion that minimizes peak flame temperatures and high oxygen pockets. Other techniques include enhanced heat transfer from the first stage to reduce combustion temperatures in the second stage and controlled second-stage combustion to further minimize peak flame temperature. As a result, the burner minimizes overall NO_x formed in the combustor.

The FIR burner was developed by GTI and several sponsors, including DOE. The FIR burner technology is licensed to Johnston Boiler Company (fired tube boiler applications), Coen Company, Inc. (packaged watertube boiler applications), and Peabody Engineering Corporation (field-erected boilers in the steel industry). The burner is applicable to a wide range of fire tube boilers from 50 to 100 MMBtu/hr. The technology is currently being tested for applications in packaged water tube boilers and multi-fuel burners for the steel industry.



Forced Internal Recirculation Burner

Overview

- ◆ Developed by the Gas Technology Institute
- ◆ Marketed by Johnson Boiler Company for fire tube boilers
- ◆ Operating on 17 boilers in 2004

Applications

Currently used in fire tube boilers and being developed for water tube boilers and field-erected boilers for the chemicals, petroleum products, food, and steel industries

Capabilities

Minimizes thermal and prompt NO_x through staged combustion with internal recirculation of products of partial combustion. Burner design is suitable for new or retrofit applications on a wide range of combustion chamber configurations.

Benefits

Emissions Reductions

Results in very low NO_x emissions, less than 9 ppm, without using diluents such as steam, water, or external flue gas recirculation.

Productivity

Increases system efficiency, with operation at less than 15% excess air over the entire turndown range of four to one.

Profitability

Reduces developmental, operating, maintenance, and capital costs compared with "current generation" low- NO_x burner systems.

IMPACTS

Innovative Aerodynamic Fairings Minimize Drag on Box Shaped Semi-Trailers

A great deal of scientific research has demonstrated that streamlining box-shaped semi-trailers can significantly reduce a truck's fuel consumption. However, significant design challenges have prevented past concepts from meeting industry needs. Freight Wing, Inc., was formed to improve fleet profitability through innovative aerodynamic devices. Freight Wing was initially funded through a grant from DOE's Inventions and Innovation Program to develop rear-fairing technology and has since expanded the company's products to a complete line of aerodynamic solutions. Their initial research focused on developing a practical rear fairing that would not interfere with the truck's operation and on investigating other means to reduce aerodynamic drag on box-shaped semi-trailers. Freight Wing market research soon revealed that the industry was not very interested in the rear fairing because that area is extremely prone to damage and durability is a primary concern.

Freight Wing also developed designs for front or gap fairings and undercarriage or belly fairings and made prototypes of all three fairing designs with their manufacturing partner, ASAP Metal Fabricators. In May 2004, Freight Wing tested all three fairing prototypes at the independently owned Transportation Research Center (TRC) in East Liberty, Ohio. TRC tested the fairings using the industry standard Society of Automotive Engineers/Technology & Maintenance Council (SAE/TMC) J1321 fuel consumption procedure Type II test. A 7% fuel savings was demonstrated on trailers equipped with all three fairings. Freight Wing arranged a testing partnership with Transport America to retrofit five of their trailers for an operational test. These tests enabled Freight Wing to identify some problems and finalize the designs. The product was marketed starting in the fall of 2004, and soon thereafter the company made its first sale of two belly fairings to a fleet called LVL, Inc., in Little Rock, Arkansas. Additional research is also underway to develop second-generation designs using different materials and aerodynamic concepts.

Overview

- ◆ Developed and marketed by Freight Wing, Inc.
- ◆ Commercialized in 2004.

Applications

The Freight Wing Fairings are used on semi-trailers to reduce the effects of aerodynamic drag.

Capabilities

- ◆ Reduces aerodynamic drag on semi-trailers.
- ◆ Retrofits on existing semi-trailers.

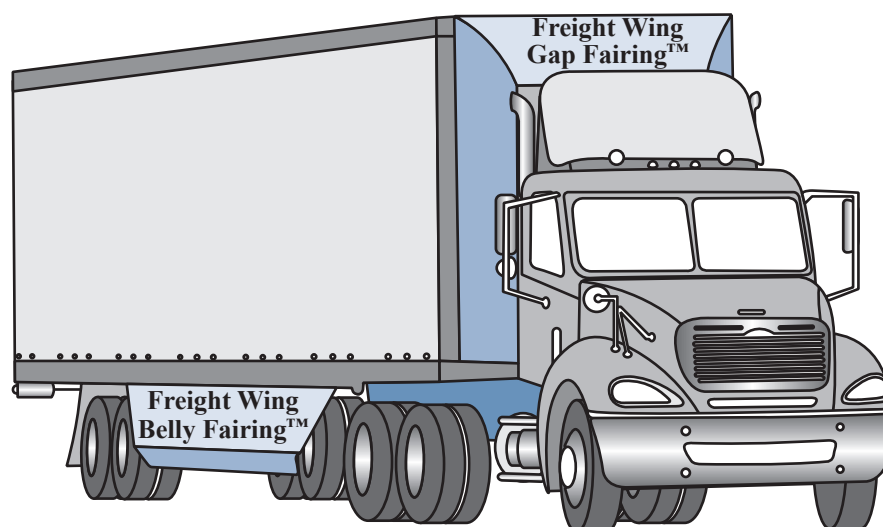
Benefits

Energy Savings

Reduces fuel usage by 7%.

Emission Reduction

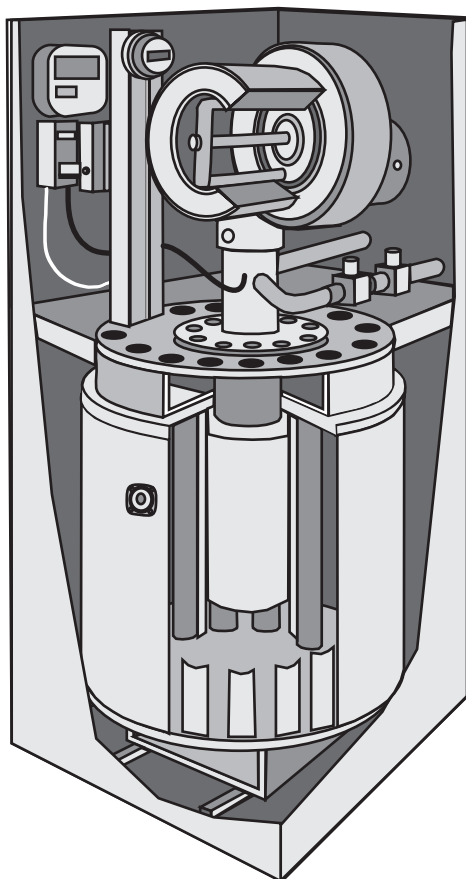
Reduces emissions of combustion products, including particulates, SO_x, NO_x, and CO₂.



Freight Wing Fairings Installed on a Semi-Trailer

ITP Development Eliminates Global Warming Gas In Semiconductor Manufacturing

The high-temperature radiant burner developed by Alzeta with ITP assistance, forms the core of a thermal processing unit that destroys up to 99.9% of one of the most potent classes of global warming gases known – the perfluorocarbons (PFCs). PFCs, which include C_2F_6 and difficult-to-destroy CF_4 , are generated during the semiconductor manufacturing process. PFCs are among the most potent greenhouse gases known, having high global warming potential and extremely long atmospheric lifetimes. For example, C_2F_6 has a warming potential 9,200 times that of CO_2 and an atmospheric lifetime of 10,000 years. The long lifetime means that even small emissions will contribute to the cumulative atmospheric global warming burden that will persist for thousands of years. The PFC destruction system, the TPU 4200, received a “best products” award from Semiconductor International magazine and is sold by Edwards High Vacuum International. Edwards selected the Alzeta burner for its ability to operate reliably at high process temperatures and provide uniform, well controlled heat. The TPU 4200 is placed downstream of semiconductor wafer etching “tools” made by Applied Materials and Novellus. Because plants have multiple tools to serve multiple production lines, several TPU 4200 units are generally installed in each plant. TPU 4200 customers include well known companies such as Advanced Micro Devices, Hewlett Packard, and Motorola, as well as several manufacturers in Japan.



High-Temperature Radiant Burner

Overview

- ◆ Developed by Alzeta Corporation
- ◆ Commercialized in 1995
- ◆ Over 5,000 burners sold in the United States

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
9.47	2.19

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.256	34.8

Applications

- ◆ Adiabatic thermal oxidizers for destroying hazardous volatile organic compounds
- ◆ Gas-fired boilers, paper dryers, refineries (asphalt heating), and plastics manufacturing (resin drying)
- ◆ Other boilers, furnaces, dryers, and combustion equipment applications

Capabilities

- ◆ Can operate reliably with higher-than-normal process temperatures.
- ◆ Has uniform and well-controlled heat flux.

Benefits

Ease of Installation

Manufactured in standard-size cylindrical segments to facilitate shipping and installation.

Pollution Control

Reduces NO_x emissions by up to 80%.

Productivity

Reduces maintenance and associated downtime in applications that require handling of hazardous gases. Increases productivity in paper drying by increasing energy delivered to drying drums.

IMPACTS

Redesigned Diesel Engines Improve Heavy Truck Fuel Economy

The KIVA computer model resulted from the efforts of a diesel engine working group formed in 1979 as part of DOE's Energy Conservation and Utilization Technologies (ECUT) Division's Combustion Technology Program. The goal of this activity was to guide the development and application of diagnostic tools and computer models. Under the guidance of DOE and the Cummins Engine Company the multidimensional KIVA model was developed to help engine designers overcome some of the technical barriers to advanced, more fuel-efficient engines.

KIVA allows designers to see the effects of alterations to engine geometry without actually building the engine. Cummins Engine Company has used KIVA to make piston design modifications and other modifications to diesel engines for heavy trucks. In a cooperative effort with DOE, Cummins has also improved engine breathing, pulse-preserving manifolds, and turbocharger design. Cummins has improved the diesel engine sufficiently to increase the mileage by nearly one-half mile/gallon. With millions of trucks and buses currently on the road, this improvement in engine efficiency yields a significant savings in fuel.

Energy savings from this development are based on the number of trucks (class 7 and 8) powered by Cummins engines. This value, multiplied by the savings per mile and the number of miles driven per year, results in the estimated annual energy savings.

Benefits

Competitiveness

Helps the United States automotive industry strengthen its competitive position relative to Europe and Japan.

Productivity

Reduces time required from engine design to production.

Waste Reduction

Optimization in engine performance considerably reduces emissions, including unburned hydrocarbons.

Overview

- ◆ KIVA computer model developed by Los Alamos National Laboratory, Sandia National Laboratories, Southwest Research Institute, and others
- ◆ Commercialized in 1991
- ◆ Cummins Engine Company is the first to use KIVA to redesign diesel engines for improved energy efficiency

Energy Savings (Trillion Btu)

Cumulative through 2004	2004
932	82.2

Emissions Reductions (Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.617	47.8	12.7	1790

Applications

- ◆ Visualizing effect of design changes on engine performance
- ◆ Assessing engine ability to use alternative fuels or reduce emissions
- ◆ Optimizing engine operation to reduce emissions

Capabilities

- ◆ Simulates precombustion fluid motion, chemical kinetics, flame propagation, and combustion dynamics in engines.
- ◆ Investigates airflow and diesel spray characteristics nonintrusively.

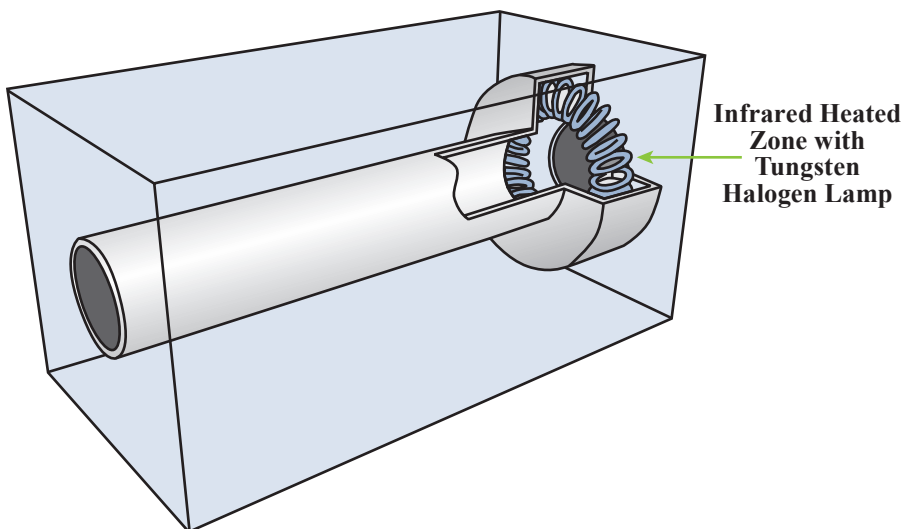
Infrared Polymer Boot Heater

IMPACTS

New Heating System Results in Fewer Repetitive Stress Injuries While Saving Energy

Employees of General Motors, Delphi Automotive Steering Systems in Athens, Alabama, suffered repetitive stress injuries from placing protective polymer boots over car steering wheel assemblies. Delphi came to Oak Ridge National Laboratory (ORNL) requesting the development of a heating technology to heat and expand the lower 2 inches of a polymer boot without using hot fluids or heating the worker or surroundings. The infrared boot heater was developed from these requirements. A tungsten halogen lamp based infrared heater goes from cold to full power in 0.2 second and shuts down in less than a second.

The technology converts electrical energy to radiant energy at 90% efficiency. The heat can be delivered to only the areas needing to be heated, and the design can be cold walled. Because the polymer expands, the force required for installation is virtually eliminated, thus reducing repetitive stress injuries. The subsequent cooling also results in an improved seal. A single infrared boot heater saves 6.25 million Btu over conventional electrical rod type heating in one year.



Infrared Polymer Boot Heater

Overview

- ◆ Developed by Oak Ridge National Laboratory
- ◆ Commercialized in 2000
- ◆ 5 units installed in the United States

Applications

Designed to heat thermoplastic and polymer boots for applications that require placing boots on steel parts (steering assemblies, CV joints, etc.)

Capabilities

- ◆ Capable of rapid heating (at 50-400°C/second) and cooling.
- ◆ Does not require any medium such as gas for transmission and is noncontact.
- ◆ The radiant energy couples only to the part of the polymer that requires it.

Benefits

Increased Productivity/Safety and Improved Product

The expansion of the polymer resulting from heating virtually eliminates the force required for installation. The subsequent cooling also results in an improved seal.

Reduced Waste and Materials

Grease formerly used for installing polymer boots is eliminated.

In-Situ, Real Time Measurement of Melt Constituents

IMPACTS

New Laser System Provides Real-Time Measurements for Improved Product Quality Control

A new probe uses laser-induced breakdown spectroscopy (LIBS) to determine the elemental constituents in an aluminum, glass, and steel melt. This probe measures continuously and in-situ at any point in the melt, thus providing spatial and temporal real-time data. The probe uses a pulsed (5-10 ns duration) Nd:YAG laser at 1064 nm that is focused, through a fiber-optic cable, into a molten aluminum sample, generating high-temperature plasma consisting of excited neutral atoms, ions, and electrons. Any chemical compounds present in the sample are rapidly separated into their constituent elements. The laser-generated plasma is allowed to cool several microseconds after the laser pulse, and then a spectrometer collects and disperses optical emissions from neutral and ionized atoms. The line radiation signal provides the concentration of each element present.

In the glass industry, both the melt and raw ingredients can be monitored. The probe has several applications in the aluminum and steel industries. For example, the probe can be used for in-line alloying to measure chemical content during a pour and for continuous and semi-continuous furnace operations to minimize the current practice of off-line sampling and measurement. In other applications, the probe can perform in-line monitoring of impurity removal from the melt, such as removing magnesium from molten aluminum, and can provide real-time data to validate computer simulations and model furnaces.

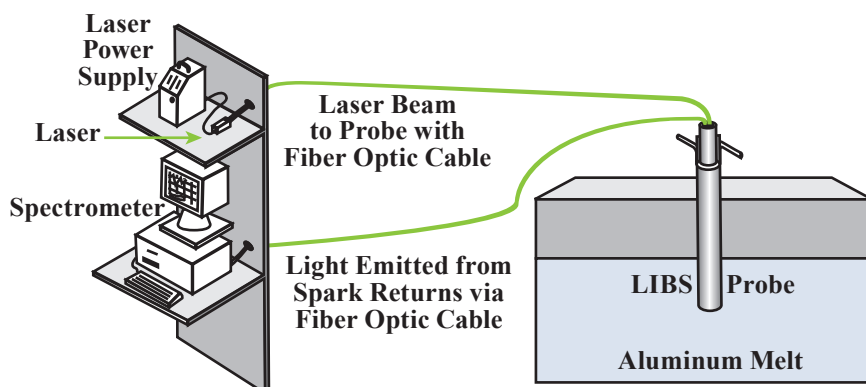
Benefits

Productivity and Profitability

Determining melt constituents and temperature in-situ, real-time, and simultaneously eliminates the aluminum and steel furnace idle time now required for off-line measurement of melt constituents. The payback has been shown to be less than one year.

Product Quality

Providing data for use in a feedback control loop to control the furnace operation in real time increases product quality.



Laser-Induced Breakdown Spectroscopy System

Overview

- ◆ Developed and marketed by Energy Research Company
- ◆ Installed on an aluminum melt furnace in 2003
- ◆ Installed in a glass plant in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.259	0.222

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.026	3.53

Applications

Identifies elemental constituents in metal and glass melts during the alloying and fabrication process

Capabilities

- ◆ Measures aluminum melt constituents with 5% accuracy and a 0.002% minimum detection limit.
- ◆ Monitors trace alkali metal content in electronic glass compositions.

New Class of High-Performance Carburized Steels Saves Energy and Increases Productivity

Various project partners have integrated an optimization of process and materials that will enable a broad usage of high-temperature carburizing. The unique capabilities of high-temperature carburizing were exploited to access new levels of steel performance, including the distortion-free, high-performance gear and bearing materials for the transportation sector. Emphasis was placed on creating a new class of thermally stable, ultra-durable, deep case-hardened steels that could ultimately extend case hardening to tool and die steels. Case hardening would enable major productivity gains in the forging, forming, and die casting of aluminum and steel.

With assistance from ITP, a consortium of project partners used their carburization simulation tools and fundamental calibration data to gain reliable control of high-temperature carburizing of their new class of high-performance gear steels. One of the partners, QuesTek, used the technology to successfully commercialize new gear steels by demonstrating both higher gear performance and acceptably reduced manufacturing variation.

Benefits

Energy Savings

Reduces the U.S. annual energy consumption for carburizing.

Environmental

Reduces greenhouse gases compared with conventional gas carburizing technology.

Productivity

Reduces scrap and eliminates the need for hard chromium plating in many applications; offers increased durability and higher performance when it replaces conventional steel.

Overview

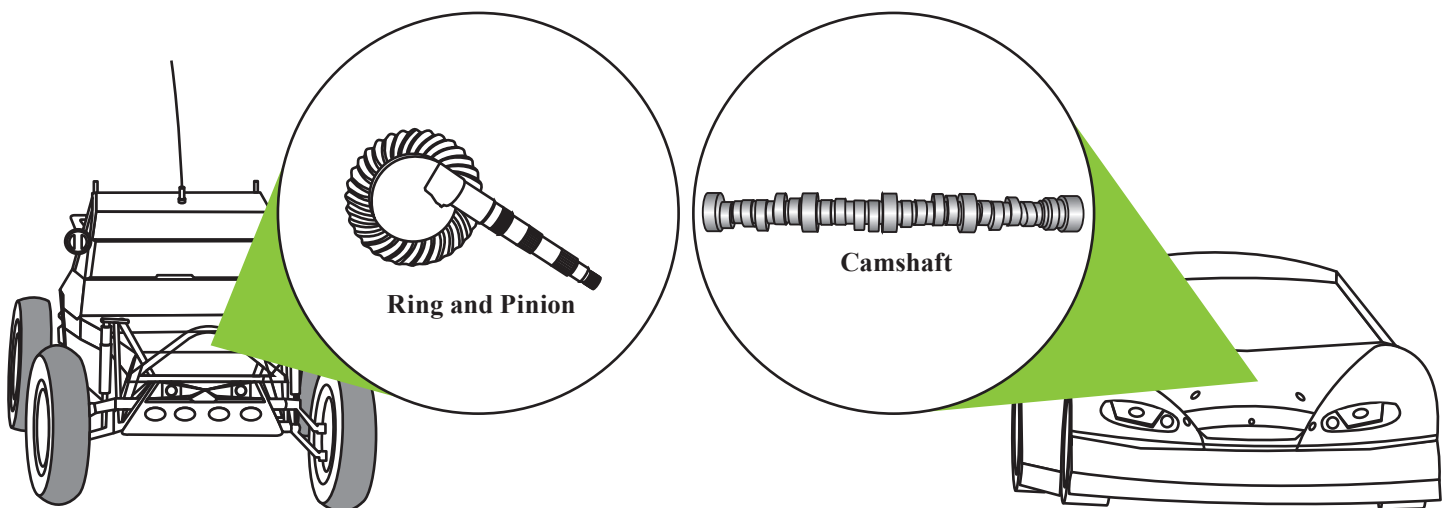
- ◆ Developed by a consortium of project partners including the Center for Heat Treating Excellence, Metal Processing Institute – Worcester Polytechnic Institute, Northwestern University, and QuesTek
- ◆ Commercialized by QuesTek in 2003

Applications

High-performance gear and bearing applications for the transportation sector. New deep-case applications include ultra-durable die materials for forging and forming of steel and aluminum and for die casting of aluminum

Capabilities

- ◆ Establishes sufficient control of high-temperature carburizing to greatly expand applications.
- ◆ Creates a new class of steels with particular emphasis on novel deep-case applications.
- ◆ Demonstrates accelerated materials and process development through the emerging technology of computational materials design.



New Gear Steel Products Created Using High-Temperature Carburizing

Method of Constructing Insulated Foam Homes

IMPACTS

An Innovative Building System That Is Energy Efficient, Structurally Sound, and Easily Constructed

The concerns of the home building industry center around increasing productivity in the construction process, improving the quality of American homes, expanding opportunities for affordable home ownership, enhancing the U.S.'s competitive position relative to global markets, and ensuring the cost-effective and energy-efficient operation and maintenance of homes.

With the help of a grant from DOE's Inventions & Innovation Program, Amhome USA, Inc., developed a method of constructing buildings that are both energy efficient and structurally sound. The new home consists of an exterior patented wall system made of expanded polystyrene (EPS) foam insulation panels with an internal steel-reinforced concrete post and beam design. This wall has an R-40 insulation panel with an internal steel-reinforced concrete post and beam design. The roof is insulated by EPS slabs sandwiched between the rafters and has an R-50 insulation value. The primary innovation of this system is the way the walls are constructed, which requires less labor compared with traditional wood-frame houses.

Benefits

Environmental

The Amhome method saves timber by using 35% less wood than frame homes and saves insulation by using recycled insulation in the roof.

Productivity/Quality

Homes using the innovative EPS foam can be built faster than traditional wood-frame homes. The homes' superstructure is reinforced with concrete and steel for more stability, and the entire house is united into one solid piece.



Concrete Being Pumped into the Wall Cavity of an Insulated Foam Home

Overview

- ◆ Commercialized by Amhome USA, Inc., in 1996
- ◆ 316 homes constructed through 2004
- ◆ Marketed by Home Corporation International, Inc.

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.033	0.005

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.001	0.093

Applications

- ◆ New single-family residences.
- ◆ New multifamily dwellings.
- ◆ Small commercial buildings.

Capabilities

- ◆ Provides an R-40 wall using EPS foam insulation panels to form the exterior walls.
- ◆ Provides an R-50 roof/ceiling using EPS foam between the rafters.

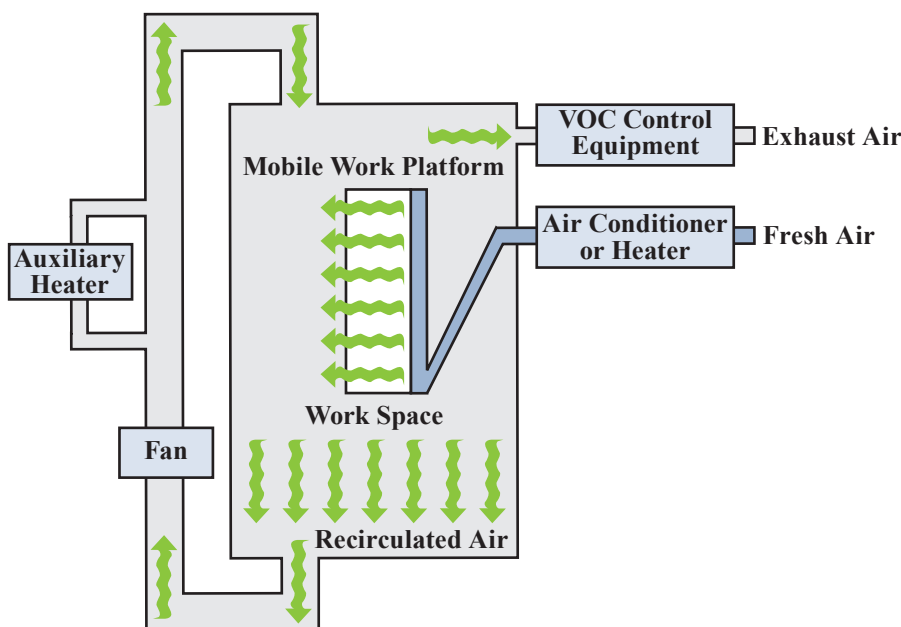
Mobile Zone Optimized Control System for Ultra-Efficient Surface-Coating Operations

IMPACTS

New Surface-Coating Technique Reduces Air Pollution and Energy Use

Volatile organic compounds (VOCs) are released during the application of spray coatings in paint enclosures, which expose workers to toxins, create air pollution emissions, and create fire or explosion hazards. To meet safety and environmental regulations, paint booths are usually ventilated with 100% outside air, which is then heated or cooled to maintain comfortable temperatures and control pollution emissions.

A new spray booth technology developed by Mobile Zone Associates with the help of a grant from the Inventions and Innovation Program greatly reduces the amount of energy needed to heat and cool ventilation air during surface coating operations. The Mobile Zone system separates the human painter from the contaminated air of the spray booth by providing the painter with a separate, mobile work platform or cab during spray coating operations. The cab is flushed with fresh air, while the rest of the spray booth uses recirculated air. The design meets OSHA regulations and National Fire Protection Association guidelines. The technology is currently being used by the US Army at Fort Hood, Texas for consideration of system wide use.



Air Flow in Paint Spray Booth with Mobile Zone System

Overview

- ◆ Developed by Mr. Clyde Smith and Mr. William Brown of Mobile Zone Associates
- ◆ 1 installation operating in the United States in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.024	0.007

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.001	0.001	0.120

Applications

Applying sprayed surface coatings to chairs, tables, motorcycles, tractors, railroad cars, aircraft, and other painted products in either side-draft or down-draft booths

Capabilities

Reduces the ventilation, heating and cooling requirements by directing a sufficient, but small, amount of fresh air to the painter and recirculated air to the remaining unoccupied space within the spray booth. Meets existing OSHA, EPA and NFPA standards for worker conditions.

Benefits

Profitability

The technology reduces the size of heating, cooling, and pollution control equipment between 60% and 98%, which offers significant savings in associated capital and energy costs.

Productivity/Product Quality

Testing has shown the technology is able to maintain or improve production speed and quality.

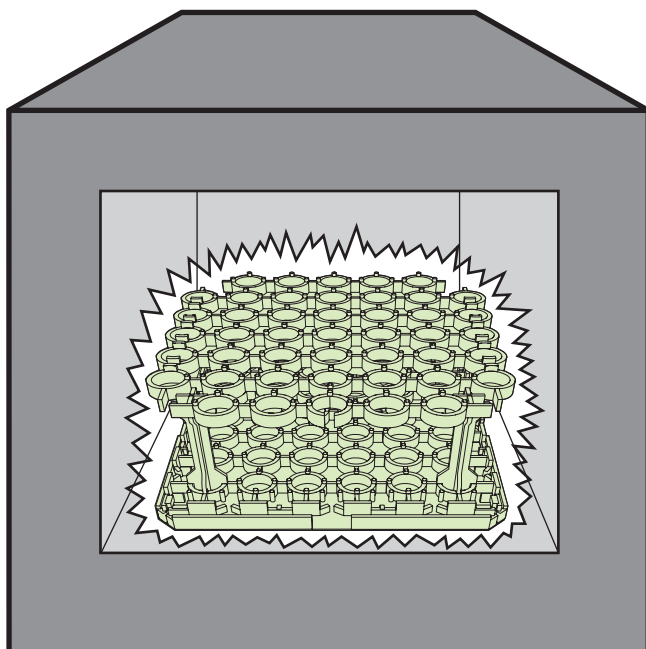
Nickel Aluminide Trays and Fixtures Used in Carburizing Heat Treating Furnaces

IMPACTS

Advanced Material Use Results in Decreases in Energy and Operating Costs

Typically, 90% of all heat treating furnace problems are caused by alloy issues such as failure of assemblies at high heat and short life of the assembly racks. Since 1992 Delphi Corporation, Oak Ridge National Laboratory, and DOE have been working together on nickel aluminide (Ni_3Al) fixtures for furnaces. The research and development has focused on nickel aluminide alloys (including alloy development) and the welding, melting and casting technologies associated with Ni_3Al .

Delphi installed 500 Ni_3Al base trays as part of their carburizing furnaces, which are very large gas-fired systems (up to 150 ft long) and heat treat hundreds of tons of steel per day. The Ni_3Al fixtures last 3 to 5 times longer than current high-performance steel alloys and are at least 3 times stronger at operating temperature than conventional alloys. These properties result in improved energy and production efficiencies. Using the stronger Ni_3Al fixtures enabled Delphi to meet production goals with only two new furnaces instead of the three that would have been required with the current technology fixtures.



Heat Treating Furnace Containing Nickel Aluminide Trays

Overview

- ◆ Developed by Delphi Corporation and Oak Ridge National Laboratory
- ◆ Commercialized in 2001 by Alcon Industries, Inc.

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.034	0.0

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.0	0.0

Applications

Nickel aluminide can be used in the heat treat industry for trays, fixtures, radiant tubes, cast link belts, rollers, fans, and miscellaneous furnace parts.

Capabilities

Nickel aluminide alloy is a high-strength heat-resistant alloy that is very resistant to carburization. The Ni_3Al fixtures last 3 to 5 times longer than current high-performance steel alloys and are at least 3 times stronger at operating temperature than conventional alloys.

Benefits

Profitability

The ability to meet production requirements in two furnaces instead of three has increased profitability by avoiding capital expenditure and reducing maintenance, energy, and alloy costs.

Reliability

The high strength and lower carburization of the trays and fixtures increase the life of the trays and has significantly decreased furnace problems.

Photovoltaic (PV) Roof Tile Assembly Delivers Clean Solar Electricity to Buildings

With the help of a grant from the Inventions and Innovation Program, PowerLight Corporation has developed the PowerGuard roofing system that offers building insulation, shading, roof protection, and solar power generation encompassed in a single roofing panel. The roofing panel includes a photovoltaic module mounted on a 3-inch-thick styrofoam board coated with a proprietary, cementitious coating. Designed specifically for flat or slightly sloped commercial and industrial building roofs, the panel works as a retrofit over existing roofs, as a new roof with new construction, and for re-roofing. The system can be tailored to capacities of 1 kW or greater and allows easy expansion.

PowerGuard installations are saving energy and money from New York to Hawaii as well as overseas. A 540-kW system installed at the Santa Rita Jail in Dublin, California reduces the jail's annual energy load by over 800,000 kWh. On the opposite coast, a 186-kW system installed atop Tompkins County Public Library in Ithaca, New York generates 200,000 kWh per year despite the fact that Ithaca receives only 60% of the solar radiation compared with Southern California. Electricity demand is reduced when it is most expensive, such as during peak demand periods on hot summer days. Reducing the load during peak demand periods also decreases the threat of blackouts and other problems associated with overloading the utility grid.

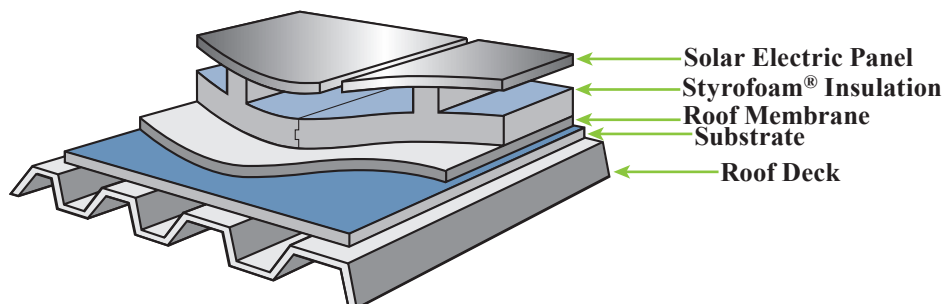
Benefits

Ease of Installation

PowerGuard can tailor systems from 1 kW up to the building's peak load and offers easy expansion. The panels use a tongue-and-groove design to interlock adjacent panels for fast installation without penetrating existing roofing material.

Product Life

The lightweight PowerGuard system is designed to survive severe weather conditions and protects the roof membrane from harsh UV rays and thermal degradation for up to 30 years, approximately doubling the life of the roof.



PowerGuard System Cutaway View

Overview

- ◆ Developed by PowerLight Corporation
- ◆ Commercialized in 1998
- ◆ Installations from New York to Hawaii and overseas.

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.247	0.097

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.021	0.016	1.91

Applications

- ◆ Installed on commercial or residential buildings that have flat or low-slope roofs
- ◆ Economical for building owners and utilities located in summer-peaking service areas where utilities offer time-of-use rates

Capabilities

- ◆ PowerGuard is a photovoltaic power system in which the photovoltaic modules are integrated with the materials used for a building's roof.
- ◆ Feeds clean AC power into the building, displacing high daytime utility rates.

IMPACTS

New Particle-Size and Concentration Monitor Leads to Efficient Use of Lower-Quality Fuels

While both gas turbines and power-recovery expanders used in petroleum power generation are efficient energy-conversion devices, fuel quality limits the application of these technologies. Widely available low-cost fuels generally contain more contaminants, which can lead to system fouling and wear as well as downtime for repair and cleaning. Without continuous monitoring for particulate contamination and feedback control, systems must be set for unknown conditions, so the more-efficient gas turbines and power-recovery expanders are not installed or, if installed, operate at lower efficiency.

With assistance from ITP and a grant from DOE's Inventions and Innovation program, Process Metrix LLC developed a real-time laser-optical process particle counter/sizer (PPC). The PPC can be used as a short-term or automated long-term sensor and control system for dust monitoring of expanders/gas turbines and process stacks. The PPC uses optical technology with fixed alignment to provide a continuous, real-time, robust, standalone particulate monitor that allows expanders and gas turbines to operate closer to optimum conditions. Such conditions improve efficiency while protecting turbines, allowing use of lower-quality fuels.

Benefits

Durability

Protects turbines from high particulate concentrations that lead to blade wear.

Emissions Reductions

Decreases emissions by improving power-generation efficiency.

Energy Savings

Could save 20 billion Btu of Natural gas per installation annually.

Productivity

Allows high-efficiency turbines to be installed in more applications and reduces production downtime from failures caused by particulate contamination.

Overview

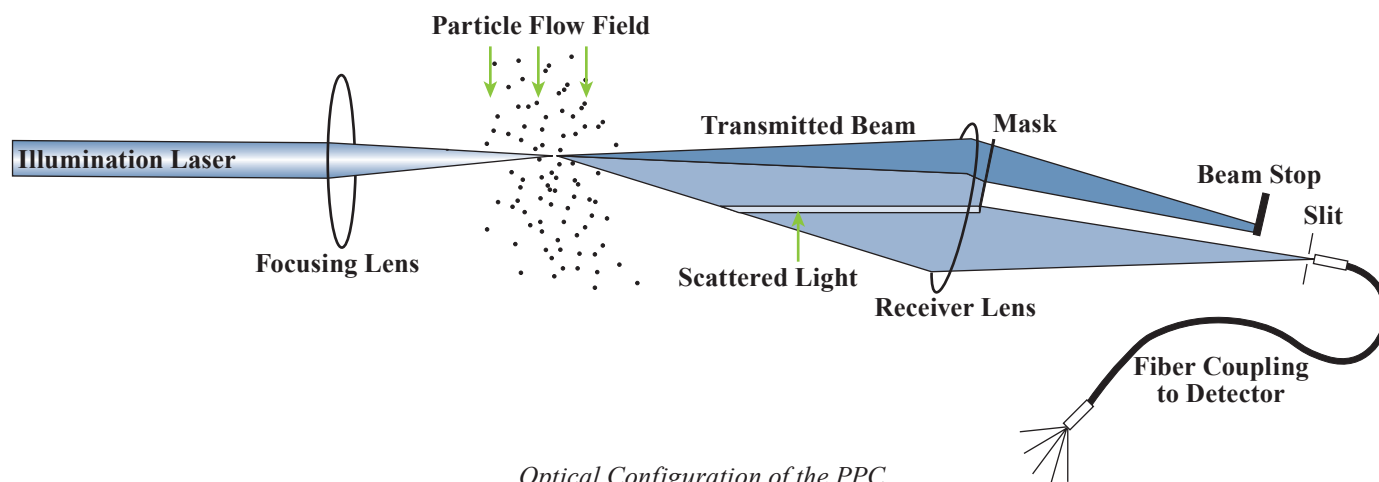
- ◆ Developed and being marketed by Process Metrix, LLC (formerly Insittec)
- ◆ Commercialized in 2004 with one unit being used for emission control by a U.S. utility

Applications

Process particle counters are applicable in petroleum power generation both for existing power recovery expanders and in situations where power recovery expanders have not been used because of unreliable fuel quality and return on investment concerns.

Capabilities

- ◆ Monitors gas-phase particle contamination at low concentration using single particle counting.
- ◆ Measures size, concentration, and velocity of gas particles in real-time.
- ◆ Operates in-situ at industrial high temperatures/pressures.
- ◆ Uses diffraction light scattering with minimum shape and refractive index sensitivity.

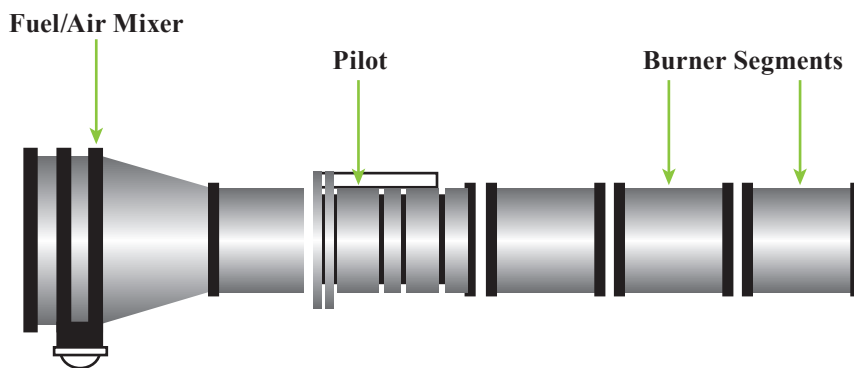


Optical Configuration of the PPC

New Burner will Deliver High Efficiency and Low Emissions in Industrial Boilers and Process Heaters

ITP and Alzeta Corporation have developed the Radiation-Stabilized Burner (RSB), an ultra-low NO_x and CO burner for applications in industrial boilers and process heaters. Characteristics of the RSB that improve performance relative to conventional burners include (1) full premixing of fuel and air to the greatest extent possible prior to combustion, (2) surface stabilization through the use of radiant zones and high flux zones on the burner surface, and (3) controlled flame shape above the burner surface. This results in low NO_x and CO emissions without sacrificing thermal efficiency or boiler reliability.

Premixing of the fuel and air before combustion provides a simple method of combusting all fuel at the desired fuel-air ratio and has been demonstrated to be an effective method of providing simultaneous low NO_x and low CO emissions. Excellent flame stability is needed to achieve low emission levels over the broad range in which industrial boilers operate. High-surface heat flux and controlled-flame shape above the burner surface allow for more compact boiler designs and for more rapid cooling of the flame to further reduce NO_x emissions.



Radiation-Stabilized Burner

Overview

- ◆ Developed by Alzeta Corporation
- ◆ Commercialized in 1999
- ◆ Since 1999, over 150 burners have been installed

Applications

Industrial boilers and process heaters with capacity ranging from 2 MMBtu/hr to 150 MMBtu/hr, which are used in refineries, pulp and paper plants, and chemical manufacturing facilities

Capabilities

- ◆ Ultra-low NO_x and CO industrial burner capable of achieving sub-9 ppm NO_x and sub-50 ppm CO emissions.
- ◆ No loss in thermal efficiency relative to current 30 ppm burner designs with high efficiency controls option.
- ◆ Stable operation over a broad range of emission levels, from sub-7.5 ppm NO_x to sub-30 ppm NO_x, with one burner design.

Benefits

Emissions Reductions

Simultaneously achieves low NO_x, CO, and unburned hydrocarbon emissions due to the fully premixed burner design.

Productivity

This simple technology approach to low NO_x emissions results in little downtime; any problems are easily repaired.

Profitability

Eliminates the need for “post-combustion” pollution-control devices to reduce the cost of NO_x compliance. Allows for more compact boiler designs due to the uniformly distributed heat flux from the RSB surface.

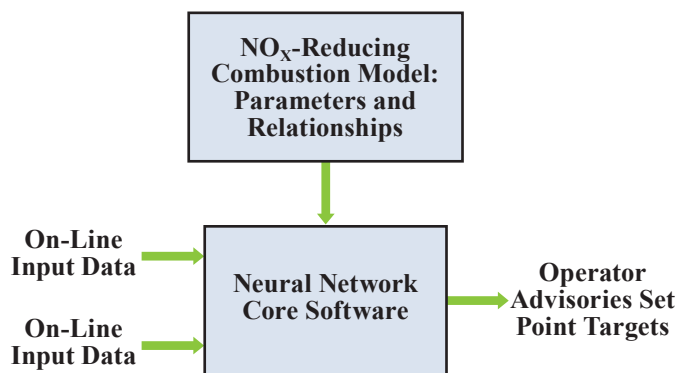
IMPACTS

Real-Time Neural Networks for Combustion Optimization of Utility Boilers Reduce Emissions

Nitrogen oxides (NO_x) resulting from the combustion of fossil fuels are damaging to the environment. NO_x emissions from coal-fired boilers, such as those used by industry and electric utilities, can be reduced through the appropriate manipulation of combustion process set points. However, it is beyond the capability of existing plant control systems to optimize these set points during actual plant operation. Using a NICE³ grant, Pegasus Technologies developed and demonstrated the NeuSIGHT[®] system to optimize combustion control settings for minimal NO_x emissions while maintaining the required exit gas temperatures, levels of unburned carbon, and flue gas corrosives. The NeuSIGHT system, part of the Delta E^{3™} portfolio of optimization strategies, is an on-line system that adapts dynamically to changes in plant operating conditions and accommodates equipment performance variations throughout typical maintenance cycles. In many cases, this approach can eliminate the need to install low-NO_x burners to meet regulatory requirements.

The computer model, which uses an advanced form of artificial intelligence known as a neural networks, has been shown to be capable of improving boiler efficiency by as much as 5% and reducing NO_x emissions by 20% to 60%. Emissions of CO₂ and SO_x would also be reduced in direct proportion to the amount of fuel saved. The cost of reducing NO_x emissions using the model is much lower than the cost of installing low-NO_x burners or catalytic converters. Pegasus Technologies forecasts that 37% of the United States pulverized coal plants and 25% of plants worldwide will use neural network systems by 2010.

Pegasus is also investigating the capability of using sophisticated control processes and advanced sensor technologies to optimize mercury speciation in order to meet new requirements coming in 2018.



*Real-Time Neural Networks for Combustion Optimization
– Process Flow Diagram*

Overview

- ◆ Developed by Pegasus Technologies
- ◆ Commercialized in 1995
- ◆ 56 units currently operating

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
57.8	11.2

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.143	6.99	3.07	310

Applications

Coal-fired boilers, particularly those with capacities of 25MW or greater

Capabilities

- ◆ Reduces NO_x emissions by 20% to 60% while maintaining or improving plant thermal efficiency and reducing SO_x and CO₂ emission levels.
- ◆ Generates set point targets that are optimized to dynamically balance the trade-offs between NO_x emissions, heat rate, and unburned carbon.

Benefits

Natural Resources

Reduces the need for new power plants for utility expansion projects, thus reducing associated impacts on land and water.

Profitability

Improved heat rate means that more electricity is produced per unit of CO₂ and SO_x emitted.

Waste Reduction

Reduces emissions of combustion products, including NO_x, SO_x, and CO₂.

New Fastening System Reduces Energy Use of Buildings

Roofing systems for industrial and commercial buildings continue to make significant strides in their performance and durability. Fasteners are essential to keeping many of these roofs intact by joining of pieces or multiple layers. However, the combination of newer roofing materials, known as singly-ply membranes, with conventional metal fasteners leads to increased heat loss. This loss occurs because the metal screw and plate of the fastener are only minimally insulated from the surroundings and conductive heat flow occurs through the thermal bridge created by the metal fastener.

The RR-1 Insulated Screw Cap Assembly, developed by The Romine Company of Newark, Ohio, with the aid of a grant from the DOE's Inventions and Innovation Program, is a simple but effective solution to heat loss and back-out problems found with many conventional fasteners. This improved fastener consists of an injection-molded fiberglass-reinforced nylon anchor, soft insulating plug, and optional grapple washer. The system is simple to install and extremely strong.

The energy advantage of the RR-1 results from the fastener depth and insulation value. The metal screw portion of the fastener is embedded at least one inch into the insulation board, reducing the heat transfer through the fastener. A foam plug is inserted in the cavity created and acts as an insulator. The new fastener design is more resistant to condensation and corrosion, which makes the fastener less likely to corrode and lose holding strength over time.

Benefits

Productivity

The simple flush mount requires less torque and time to screw in (no predrilling required) and provides a smoother finish than conventional fasteners. The RR-1 is also produced from less costly materials, so it is a more economical choice than other all-plastic fasteners.

Durability

In tests conducted on wind uplift, the strength of the RR-1 insulating fastener proved to be greater than the holding power of the metal decking. The RR-1 fastener also resists back-out. These features, and fastener tear-out, are particularly critical with the newer flexible membrane roofing materials.

Overview

- ◆ Developed and marketed by The Romine Company
- ◆ Commercialized in 1997
- ◆ 275,200 units sold through 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.008	0.002

Emissions Reductions

(Thousand Tons, 2004)

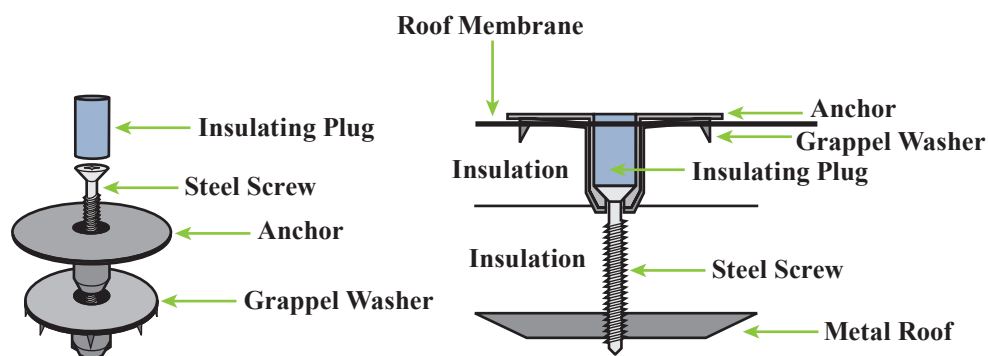
Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.0	0.034

Applications

The technology may be used on commercial and industrial buildings with membrane roofs and metal roofs. The screw caps may also be applied as a retrofit to older roofs.

Capabilities

- ◆ Replaces conventional metal or plastic fasteners to improve the energy performance in building roofs.
- ◆ Optimized for fastening single-ply roofing or rigid insulation to metal decking.
- ◆ Resists typical problems for fasteners including back-out and corrosion.



The RR-1 Insulated Screw Cap Assembly

Solid-State Sensors for Monitoring Hydrogen

IMPACTS

New Sensors Rapidly and Accurately Detect Hydrogen, Improving Industrial Safety and Efficiency

Molecular hydrogen, H_2 , is a combustible gas that is produced in large quantities by many industries and has a broad range of applications. When H_2 is an undesirable contaminant, a monitor must be able to detect concentrations on the order of parts per million (ppm). In other cases a monitor must be usable in nearly pure hydrogen. Although gas chromatography and mass spectrometry are widely used for detecting H_2 , these methods require bulky, expensive equipment.

Using solid-state technology developed at the U.S. Department of Energy's Sandia National Laboratory, H2scan LLC is now commercializing hydrogen-specific sensing systems that can detect hydrogen against virtually any background gases. These hydrogen-sensing devices can detect hydrogen in 1 to 10 seconds, thus allowing the devices to be used in control systems. Currently, H2scan offers three hydrogen-sensing system configurations: a hand-held portable leak detector, a fixed-area monitoring system, and an in-line real-time concentration analyzer.

The advantages of the H2scan hydrogen sensors are in their operating parameters. The sensors have a low hydrogen sensitivity of about 5 ppm in air and less than 1 ppm in nitrogen. They are hydrogen specific with no cross-sensitivity to other gases. The upper range of the sensor is 100% with an extremely fast speed of response. They operate between -40°C to 150°C , making them attractive for virtually all sensor applications.

Benefits

Energy Savings

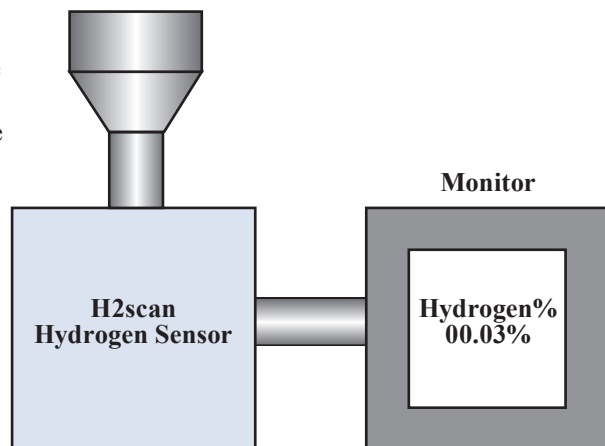
Hydrogen plays a critical role in float-glass manufacturing, an energy-intensive industry that produces 2.6 million tons of glass per year. Improper monitoring can substantially increase defects and waste energy.

Productivity

The solid-state devices can detect hydrogen in 1 to 10 seconds, which is suitable for interfacing to control systems. Using the device to monitor hydrogen in feedstock of a refinery feed hydrogen/carbon monoxide facility could improve overall performance by up to \$250,000 per year per plant.

Profitability

Solid-state sensors can be mass-produced, making them much less expensive than competing sensors. Small sensor dye produces a system that is much smaller than traditional sensors.



H2scan Hydrogen Monitoring System

Overview

- ◆ Developed by Sandia National Laboratory and H2scan LLC
- ◆ Commercialized in 2004
- ◆ Over 300 units sold in 2004

Applications

- ◆ Monitoring trace levels of H_2 in high-purity feed gases for chemical processes
- ◆ Monitoring hydrogen production from methane and refinery offgases, where the hydrogen is often mixed with carbon monoxide
- ◆ Monitoring hydrogen levels in transformer oil to detect when the oil starts breaking down
- ◆ Measuring the hydrogen given off from lead acid batteries due to overcharging to stop a buildup of hydrogen and reduce the threat of either a fire or explosion
- ◆ Monitoring and control of hydrogen, which are crucial to obtain the correct molecular-weight distributions in the gas-phase polymerization of polyethylene and polypropylene
- ◆ Analyzing fugitive hydrogen emissions in ambient plant environments or in materials subjected to high-energy radiolysis, which is crucial for safety in those environments
- ◆ Measuring hydrogen levels to control the efficiency of fuel cell reformers

Capabilities

- ◆ Can be used over a wide range of hydrogen concentrations with minimal interference from other gases.
- ◆ Provides rapid response time of 1 to 10 seconds, allowing them to be used for process control.

Unique Twisted Design of Ceramic Insert Saves Energy for Metal Heat-Treating Furnaces

Radiant tube heaters are typically used in metal heat-treating furnaces. The heaters are long tubes, often in a U shape, which have natural-gas fired burners at one end of the tube (the burner leg) to produce a flame and heated gas that flows through the tube to produce heat for conditioning metals (e.g., strengthening them or otherwise changing some of their properties). In a traditional radiant tube, the burner leg releases 30% more energy than the exhaust leg because of convection and radiation heat transfer in the burner leg.

With the help of a grant from DOE's Inventions and Innovation Program, STORM Development LLC and Sycore, Inc., optimized the SpyroCor, a ceramic (silicon-carbide) insert for the exhaust leg of the tube heater. The patented twisted design of the SpyroCor produces nonturbulent, high convection flow that produces the highest possible rate of uniform heat transfer. As a result, the SpyroCor reduces heat loss and the energy demands of the process by 15% to 20%. A typical furnace contains 10 radiant tubes, which use an average of 3 SpyroCors per tube. Through 2004, 77 furnaces have been equipped with SpyroCors for a savings of 300 billion Btu.

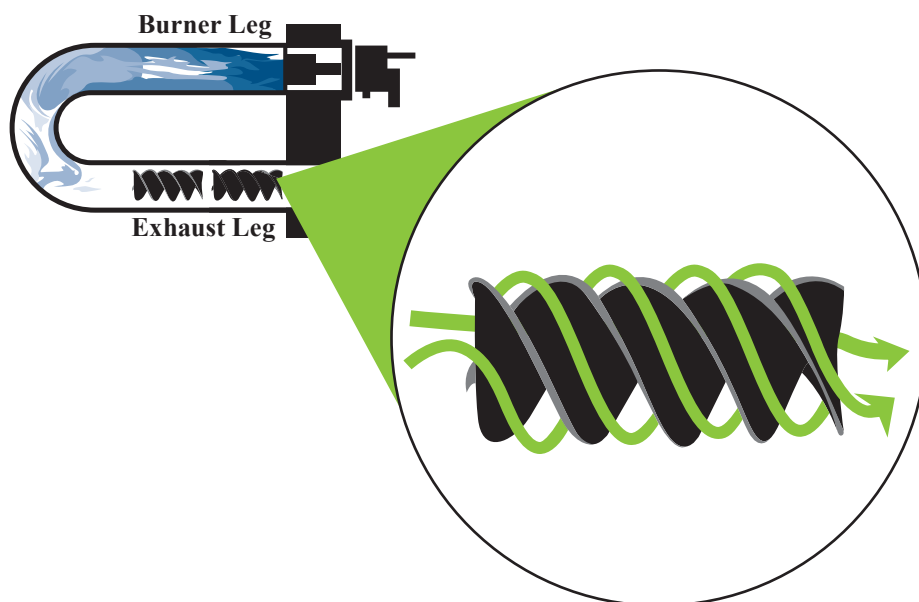
Benefits

Ease of Installation

Can be quickly and easily inserted into existing heater tubes without overhauling the entire furnace.

Productivity

Allows the furnace user to increase the amount of metal treated for the same amount of energy used or to reduce the amount of energy used for the same output.



SpyroCor Installed in a Radiant U-Tube Heater

Overview

- ◆ Developed by STORM Development LLC and SyCore, Inc.
- ◆ Commercialized and being marketed by Spinworks LLC
- ◆ More than 2300 units sold through 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.300	0.300

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.035	4.77

Applications

To be inserted into radiant tube heaters typically used in metal heat-treating furnaces that use natural gas burners.

Capabilities

- ◆ Produces nonturbulent, high convection flow in the radiant tube.
- ◆ Doubles the amount of surface area available for heat transfer.
- ◆ Balances the heat transfer throughout the radiant tube, allowing more energy to be available to the load.

SuperDrive – A Hydrostatic Continuously Variable Transmission (CVT)

IMPACTS

Unique Measurement System Enhances Process Control, Reduces Scrap, and Saves Energy

The heavy-duty truck (class 7 and 8) market is dominated by standard-geared transmissions. Standard transmissions are so efficient that little interest has been shown in exploring even greater efficiencies using other types of transmissions. With assistance from the DOE's Inventions and Innovation Program, SuperDrive, Inc., addressed increased efficiency by developing a hydraulic transmission system to uncouple engine rpm from wheel speed. This design allows the electronic control module to seek the lowest rpm at which sufficient torque is available to maintain the desired speed.

The patented SuperDrive system uses an axial piston, variable hydraulic pump that is coupled to the crankshaft at the rear of the engine. The pump drives axial-piston variable motors connected to the drive shaft. With an electronic control module, SuperDrive maintains the lowest rpm possible to produce sufficient torque to maintain required pump output. If demand increases, the fuel flow to the engine increases to meet demand, but engine speed is increased only as a last resort. This method allows the vehicle to maintain a constant speed over varying terrain with little or no increase in engine rpm. Because this is a closed-loop hydraulic system incorporating variable pumps and motors, it has the capacity for hydraulic braking by activating a flow control valve. The improved fuel efficiency, an average of 25% to 40%, more than offsets the reduction in transmission efficiency for heavy-duty trucks.

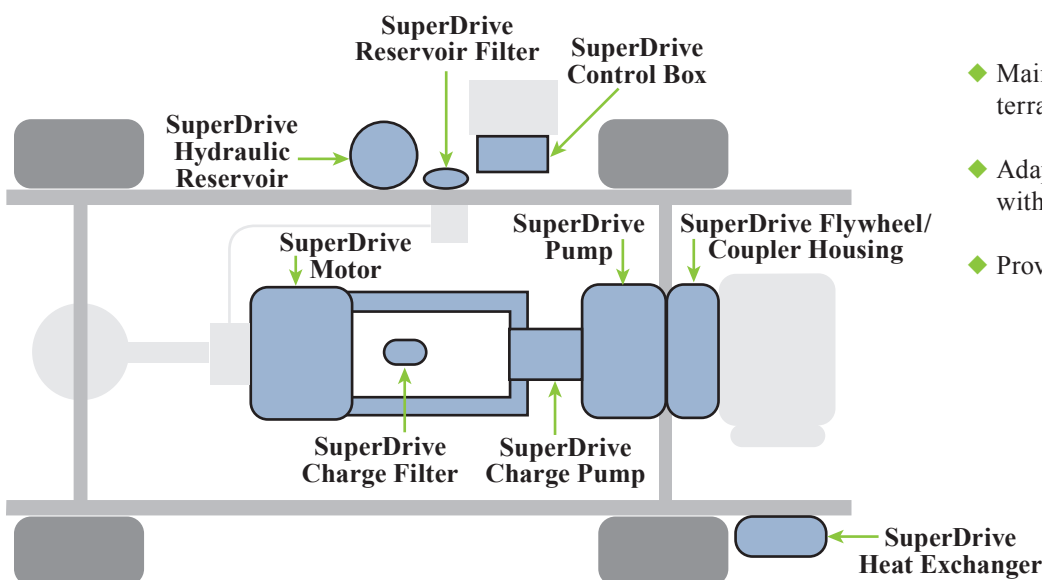
Benefits

Environmental

Reduces emissions by up to 35% over conventional long haul operations.

Productivity

Reduces driver fatigue and the need for drivers skilled in using multi-gear standard transmissions.



SuperDrive Components

Overview

- ◆ Developed and marketed by SuperDrive, Inc.
- ◆ Commercialized in 2004
- ◆ Currently installed on three transit buses in Paducah, KY

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.001	0.001

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.001	0.0	0.024

Applications

The SuperDrive system can be used in heavy-duty truck and bus engines in long-haul and fleet applications.

Capabilities

- ◆ Maintains constant speed over varying terrain with minimal increase in rpm.
- ◆ Adapts to unique characteristics or trucks with different engines and transmissions.
- ◆ Provides hydraulic braking.

Thin Wall Casting of Stainless Steel

IMPACTS

New Alloy Allows Use of Improved Casting Method

A new alloy of cast stainless steel composition was developed at the Oak Ridge National Laboratory in conjunction with GM-Powertrain and Alloy Engineering and Casting. The new stainless steel composition is optimized for its liquid metal fluidity, high-temperature creep strength, thermal fatigue resistance, and higher-temperature oxidation resistance. The alloy fluidity allows it to be cast by the Hitchiner process – a process also known as counter-gravity casting – in which ceramic molds are manufactured from wax patterns, inverted, and then filled with molten metal (via pressure) from the bottom to the top. Using the Hitchiner process allows components to be cast with wall thickness of less than 3 mm – nearly two to three times less than conventional sand casting. The process also allows automation and high product quality and yield. The optimized alloy improved component life nearly five-fold. The current commercial application is the production of exhaust manifolds for GM.

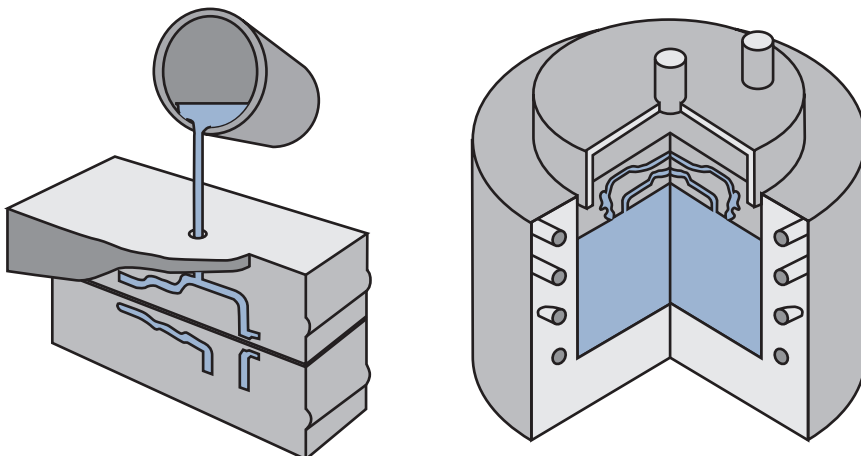
Benefits

Productivity

The Hitchiner process increases automation, increases throughput by a factor of two to three compared with the conventional process, and produces a significantly higher yield with very low defect rates.

Product Quality

The fluidity of the optimized alloy composition permits it to be cast into complex shapes by the counter-gravity Hitchiner process. This process enables higher metalcasting process yield than conventional sand casting.



Traditional Casting vs. Counter-Gravity Casting

Overview

- ◆ Developed by Oak Ridge National Laboratory in conjunction with GM-Powertrain and Alloy Engineering and Casting
- ◆ Commercialized in 2000 with more than 100,000 parts cast in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.461	0.061

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.013	0.010	1.20

Applications

New alloy allows the use of the Hitchiner counter-gravity casting process for stainless steel parts rather than conventional sand casting

Capabilities

- ◆ Easy-to-install modular system.
- ◆ Specifically optimized for the Hitchiner metal-casting process.
- ◆ Excellent oxidation resistance (i.e., resistant to exhaust gases at temperatures exceeding 1000°C) and thermal and fabrication properties.

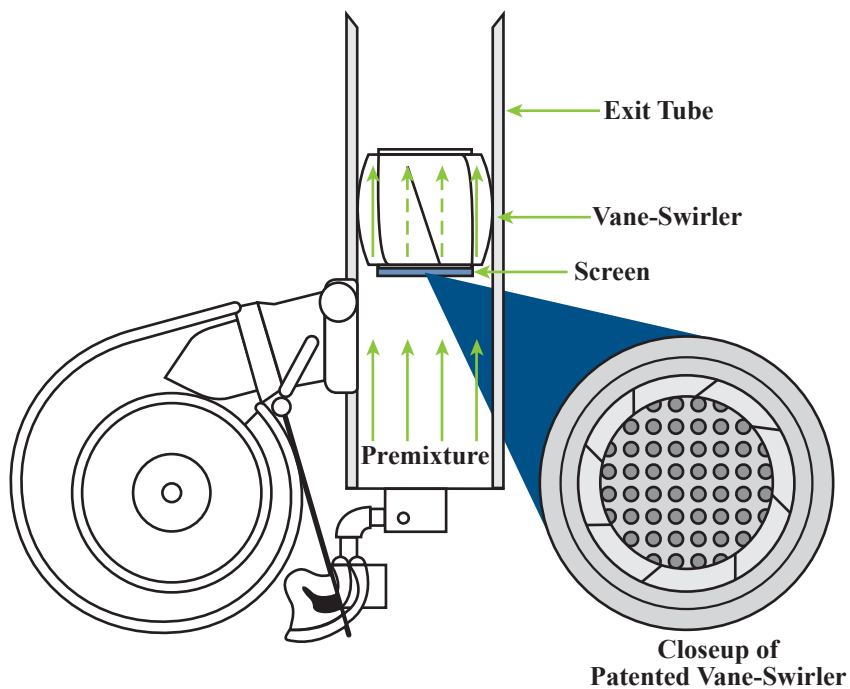
Ultra-Low NO_x Premixed Industrial Burner

IMPACTS

Reduction of Burner NO_x Production with Premixed Combustion

Industries that are dependant on combustion processes are faced with more stringent environmental regulations to reduce NO_x emissions. Some states require NO_x emissions reductions as great as 90% for chemical and refining industries. The recently developed M-PAKT™ Ultra-Low NO_x Burner uses lean premixed combustion gases and low swirl flow of combustion gases to achieve NO_x emissions levels <10 ppm (an NO_x reduction of 80% to 90%).

The research for this technology originated at Lawrence Berkeley National Laboratory with funding from the DOE Office of Science Experimental Program and Industrial Technologies Program. This new burner's distinct characteristic is a detached flame that is lifted above the burner, providing the capability for more complete combustion with less emissions. This burner concept can be applied to a wide range of combustion systems including furnace and boiler applications, gas turbines, and liquid process heaters for the chemical and refining industries. The burner can be operated with natural gas, biomass gas, and pre-vaporized liquid fuels. The burner is scalable and simple in design with no need for costly materials for manufacturing and installation. Maxon Corporation has licensed the technology for industrial process heaters used in many industrial baking and drying ovens. Applications have also been successfully tested in smaller-diameter domestic heater units.



M-PAKT Ultra-Low NO_x Burner Installation

Overview

- ◆ Developed by LBNL with two patents issued.
- ◆ Installed in the U.S. and overseas.
- ◆ Technology licensed to Maxon Corporation and sold as the M-PAKT burner.
- ◆ Estimated to reduce NO_x by almost 38,000 pounds for 2004.

Applications

The novel ultra-low NO_x burner concept can be used on a wide range of combustion systems:

- ◆ Furnaces and boilers
- ◆ Chemical and refining industry process heaters
- ◆ Gas turbines.

Capabilities

Reduces thermal NO_x in the combustion zone.

Benefits

Adaptability

Burns different gaseous fuel types and blends. Can be scaled to different sizes of units and adapted to different orientations and sizes of various flue configurations.

Low Cost

Offers low cost for manufacturing compared with traditional low NO_x solutions because the components are simple and are made from conventional materials.

Pollution Reduction and Energy Efficiency

Typically reduces NO_x to less than 10 ppm without compromising energy efficiency.

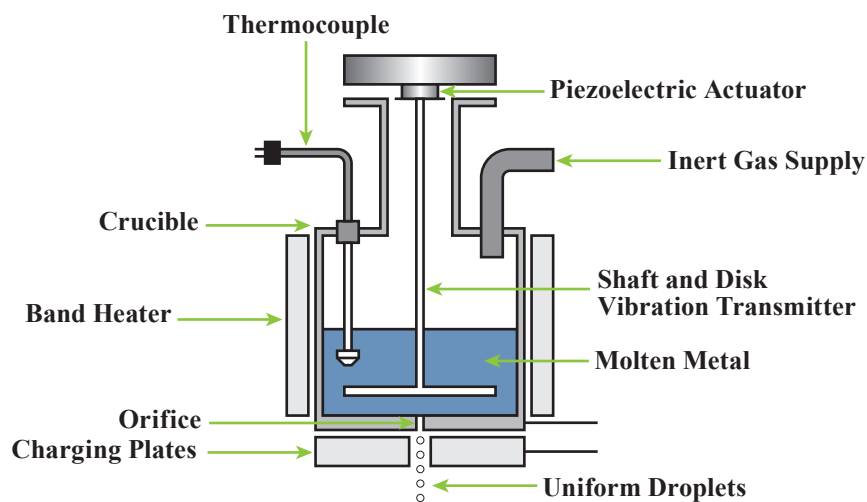
Uniform Droplet Process for Production of Alloy Spheres

IMPACTS

New Process Allows High-Quality Production of Uniform Alloy Droplets

The Uniform Droplet Spray (UDS) process is a nongas atomization process that uses the concept of controlled breakup of a laminar jet to produce uniform alloy droplets with identical thermal histories. This controlled breakup is similar to that used in ink-jet printing technology and produces monosized droplets. The droplets are solidified along a path that produces a desired microstructure. Unlike other methods for producing thermal sprays, the spray parameters in this process are fully decoupled and, therefore, permit materials processing under conditions inaccessible by conventional thermal spray processes.

With support from ITP, Oak Ridge National Laboratory, the Massachusetts Institute of Technology, and Northeastern University have developed this process that is now being commercialized for various applications. With appropriate engineering, novel particulate materials can be produced at reasonably high production rates and low capital and operating costs. Currently, the major commercial use is to produce micro-solder balls for Ball-Grid Array electronics packaging, which are used for manufacturing and assembling electronic products.



Uniform Droplet Spray Process

Overview

- ◆ Developed by Oak Ridge National Laboratory, the Massachusetts Institute of Technology, and Northeastern University
- ◆ Currently licensed to three United States and three Japanese firms who are exploring the Ball Grid Array application

Applications

Directly benefits the integrated circuit packaging industry with potential applications for use as a filtering media in the chemicals and petroleum industries

Capabilities

- ◆ Offers high quality production of uniform alloy droplets.
- ◆ Saves significant time and energy over traditional methods relying on cutting and milling operations.

Benefits

Product Quality

Produces uniform alloy droplets.

Profitability

Reduces labor costs compared with traditional cutting and milling operations.

Quality Control

Increases quality control because of the consistency of solder ball production.

Uniformly Drying Materials Using Microwave Energy

IMPACTS

New System Uses Microwave Energy to Dry Materials Uniformly at Half the Cost

Industrial Microwave Systems LLC with assistance from a Department of Energy NICE³ grant, successfully demonstrated and is commercializing an innovative system that uses microwave energy to dry materials. Traditionally, microwave-drying systems have scorched the portions of materials that were close to the radiation source while materials further from the source remained moist. This result is due to a primary characteristic of microwave energy—it attenuates as it leaves its point of origin, creating hot spots across the materials being dried. This characteristic has kept microwave drying from becoming the drying technology of choice.

This new technology addresses these traditional problems by using a rectangular wave-guide. This guide is slotted and serpentine to maximize the exposure area of materials as they pass through the system. A number of wave-guides can be cascaded to form a system that dries an entire piece of fabric or other material. Leakage of microwave energy is greatly reduced by using choke flanges to limit the amount of radiation reaching outside openings.

Benefits

Energy Savings

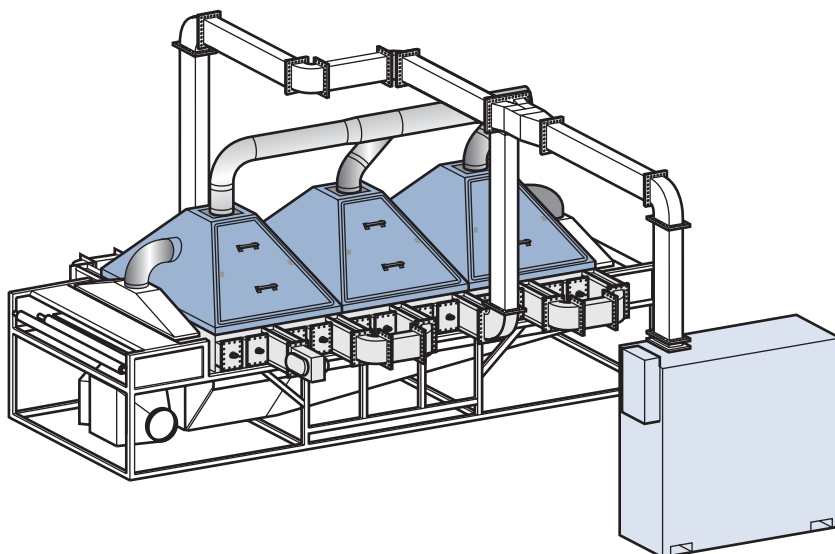
Reduces natural gas heating requirements by 20% to 50% saving up to 12 billion Btu/year for a typical plant.

Pollution Control

Reduces greenhouse gas emissions by approximately 50% with 68% of particulates eliminated.

Productivity and Profitability

Reduces drying stress because of no contact drying, lower maintenance costs because of fewer movable parts.



Microwave-Drying System

Overview

- ◆ Developed by Industrial Microwave Systems LLC
- ◆ Commercialized in 2000
- ◆ Currently operating at 5 facilities in the United States and 1 in Germany
- ◆ Two demonstration units being tested in Georgia and North Carolina

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.107	0.030

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.001	0.004	0.493

Applications

- ◆ Fabrics, leather-good linings, and shoes
- ◆ Cleaning cloths
- ◆ Industrial filters and insulation
- ◆ Medical adhesives, dressings, and gowns
- ◆ Paper products
- ◆ Geotextiles, carpeting, and roofing materials
- ◆ Personal hygiene products such as diapers

Capabilities

- ◆ Provides efficient and uniform drying of materials continuously fed through the drying system.
- ◆ Works with existing systems to reduce conventional natural gas or electric drying needs.
- ◆ Reduces microwave leakage with the use of choke flanges.

Variable-Frequency Microwave Furnace

IMPACTS

New Microwave Furnace Shows Promise in a Variety of Materials Applications

Microwave heating can speed the curing of thermo-setting resins and polymer-matrix composites. Conventional microwave furnaces use standing waves that create a non-uniform energy distribution in the working cavity. Lambda Technologies and ITP have developed MicroCure™, a variable-frequency microwave furnace that eliminates non-uniform energy distribution and provides reproducible heating with every batch. By sweeping the frequency over a range, the power distribution becomes uniform because of the superposition of thousands of individual microwave modes.

Various types of polymer products can be uniformly cured, often in 5% of the time of conventional processing. For example, the new furnace has reduced the curing time of net-shaped polymer matrix composites from 10 hours to 30 minutes. The new furnaces have been scaled up to hold large volumes of materials in the microwave cavity while still producing high-quality products and maintaining excellent process control.

MicroCure furnaces are being used in the electronics industry to manufacture circuit boards. Because the MicroCure furnace operates at lower temperatures than conventional furnaces, the stress on circuit board components such as silicon chips is reduced. In addition, circuit board manufacturers using the MicroCure furnace can replace conventional adhesives with solventless adhesives requiring lower curing temperatures, reducing emissions caused by conventional solvents.

Benefits

Competitiveness

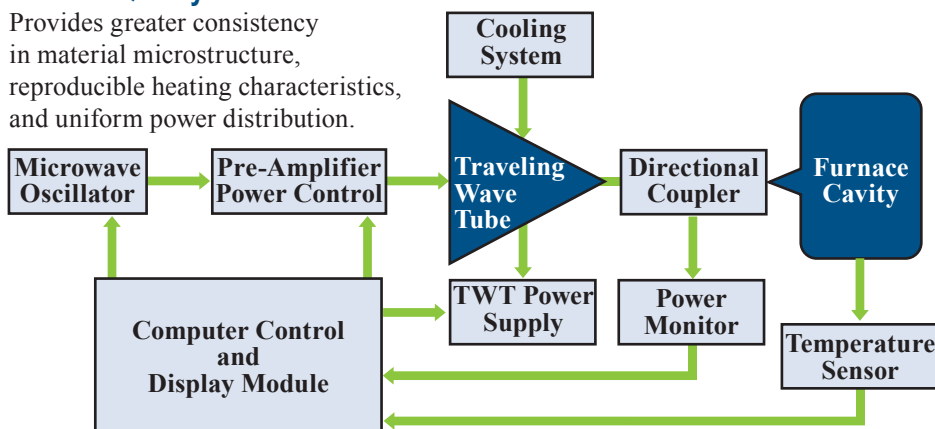
Control of the reaction rate by coupling microwave energy at the molecular level allows new material structures not possible with conventional heating techniques.

Productivity

Reduces the time required for heat treatment by up to 95% over conventional furnaces.

Product Quality

Provides greater consistency in material microstructure, reproducible heating characteristics, and uniform power distribution.



Variable Frequency Microwave Furnace System Block Diagram

Overview

- ◆ Developed by Lambda Technologies
- ◆ Commercialized in 1994
- ◆ 80 units installed, 47 in the United States

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.047	0.009

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.002	0.002	0.186

Applications

- ◆ Developing new materials and materials processes, including epoxy curing, ceramic sintering, polymer matrix composite processing, composite joining and/or fusing and surface treatments
- ◆ Plasma processing, including chemical vapor deposition, chemical vapor infiltration, and surface cleaning and modification
- ◆ Drying large volumes of textiles, ceramics, and rubber products
- ◆ Biomedical processing, including sterilization and uniform thawing

Capabilities

- ◆ Can operate at a fixed, preset frequency over a range of 1 to 18 GHz or in controlled swept frequency mode.
- ◆ Has power levels ranging from 700 W to 2 kW.

Waste Fluid Heat Recovery System

IMPACTS

Heat Recovery System Extracts Energy From Waste Fluids

With assistance from DOE's Inventions and Innovation Program, WaterFilm Energy, Inc. developed a new coil and tube design for heat exchangers that increases heat transfer coefficients two to four times higher than conventional designs. Named the GFX system, the unit is a double-walled, self-vented, copper heat exchanger that forces fluid to flow as a film. Gray water or waste streams flow through the inner drain section, while makeup or incoming water supply flows through the outer coiled jacket. The design, IAMPO- and UL-approved, incorporates equal flow rates on both sides of the heat exchanger for optimum efficiency. GFX's lack of internal welds eliminates cross-contamination problems caused by weld failures and tube leaks common to shell and tube heat exchangers. A common industrial application is to cool effluent to meet environmental or waste treatment regulations. Eliminating the potential for cross-contamination, ensures low maintenance costs and guarantees consistent energy savings.

Benefits

Energy Savings

Reduces energy consumption by recovering heat usually lost through disposal of waste. Can recover up to 70% of the heat carried to settling ponds or sewers. Hospitality industry installations have demonstrated a simple payback of 1.7 years.

Other

Preheating potable water for dairy cattle increases fluid intake and boosts milk production. Cooling wastewater sent to settling or holding ponds reduces the evaporation rate, cutting down the release of foul aromatics.

Productivity

Reduces scale formation and maintenance required to maintain boiler peak efficiency.

Profitability

Has lower first costs and operating costs than buying and maintaining larger or multiple-process heating units or systems.

Overview

- ◆ Invented and developed by WaterFilm Energy, Inc.
- ◆ Commercialized in 1997
- ◆ Over 2250 units installed in the United States

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.088	0.025

Emissions Reductions

(Thousand Tons, 2004)

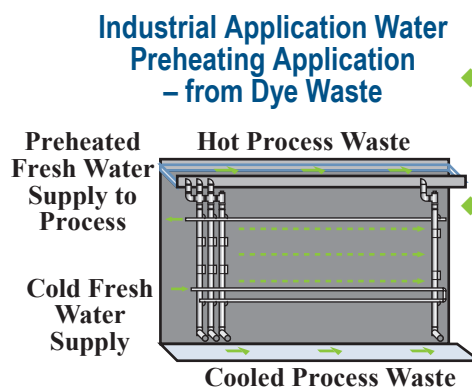
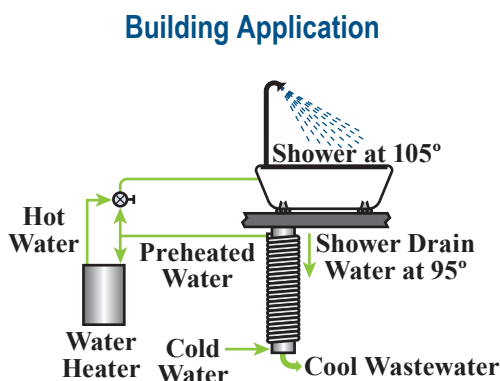
Particulates	SO _x	NO _x	Carbon
0.0	0.003	0.003	0.440

Applications

- ◆ Agricultural, chemical, refining, textile, food preparation, and other processing industries requiring heated supply water for processing
- ◆ Commercial buildings, heat recovery to complement electric and boiler water-heating systems
- ◆ Single and multifamily residential building water-heating systems

Capabilities

- ◆ Can be installed on nearly any system between the drain and sewer or holding pond.
- ◆ Units come in several sizes and can be clustered to create an "energy recovery wall" for larger facilities.
- ◆ Design promotes self-cleaning, and low residence time prevents unwanted biological growth or fouling.



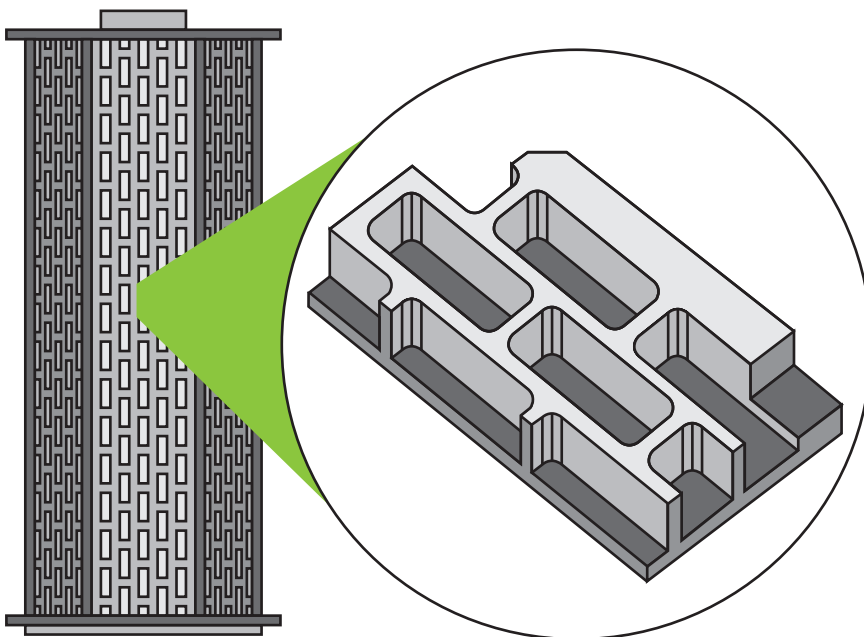
Waste Fluid Heat Recovery System

Waste-Minimizing Plating Barrel Increases Productivity

Plating barrels are used in metal plating operations to hold the parts to be plated. Traditional barrel designs have a wall thickness ranging from 1/2 to 1 inch, with thousands of holes drilled into the walls to allow electrical current and plating solution into the vessel. The wall thickness is required to provide adequate structural integrity. However, it lowers the efficiency of transferring plating solution into and out of the barrel and diminishes the ability to push electrical current through the holes and onto the parts being plated.

The Whyco barrel, developed by Whyco Technologies, Inc. and demonstrated using a NICE³ grant, is constructed by machining a staggered pattern of rectangular-shaped pockets into the traditional thick-walled polypropylene barrel. After machining, the barrel's structure resembles a honeycomb formation into which thousands of small, now shorter, holes are drilled. This patented staggered-cell design allows for the greatest number of holes per open area while maintaining structural integrity. This thin-walled honeycomb structure increases the hydrodynamic pumping action during barrel rotation, creating greater solution transfer than the traditional barrel design. The Whyco barrel also has higher current density plating leading to faster plating cycles, reduced bath concentration due to higher mass transfer rates, and better plating of difficult chemistries such as alloy plating.

To date, more than 1000 of these innovative barrels are in use at Whyco and other plating companies.



Whyco's Staggered-Cell Design

Overview

- ◆ Developed by Whyco Technologies, Inc.
- ◆ Commercialized in 1997
- ◆ Currently 1097 plating barrels in use

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
3.01	0.524

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.002	0.078	0.077	9.69

Applications

Metal-plating operations; metal finishing and electroplating

Capabilities

Increases process efficiency of metal plating operations.

Benefits

Energy Savings

Energy savings from reduced process time and better plating efficiency.

Productivity

Reduces process time and increases productivity by more than 22%.

Use of Raw Materials

Due to better plating efficiency, product yields have improved by up to 40% while cycle times have decreased by up to 25%.

Waste Reduction

Because this process reduces drag-out (drag-out refers to the chemical solution held in barrel holes by capillary action) barrel users have reported up to a 60% decrease in plating solution loss.

IMPACTS

◆ Absorption Heat Pump/Refrigeration Unit	102
◆ Advanced Membrane Devices for Natural Gas Cleaning	103
◆ Brick Kiln Design Using Low Thermal Mass Technology	104
◆ Continuous Cascade Fermentation System for Chemical Precursors.....	105
◆ Energy-Efficient Food Blanching	106
◆ Ink Jet Printer Solvent Recovery	107
◆ Irrigation Valve Solenoid Energy Saver.....	108
◆ Restaurant Exhaust Ventilation Monitor/Controller	109
◆ Stalk and Root Embedding Plow	110
◆ Textile Finishing Process	111
◆ Utilization of Corn-Based Polymers	112

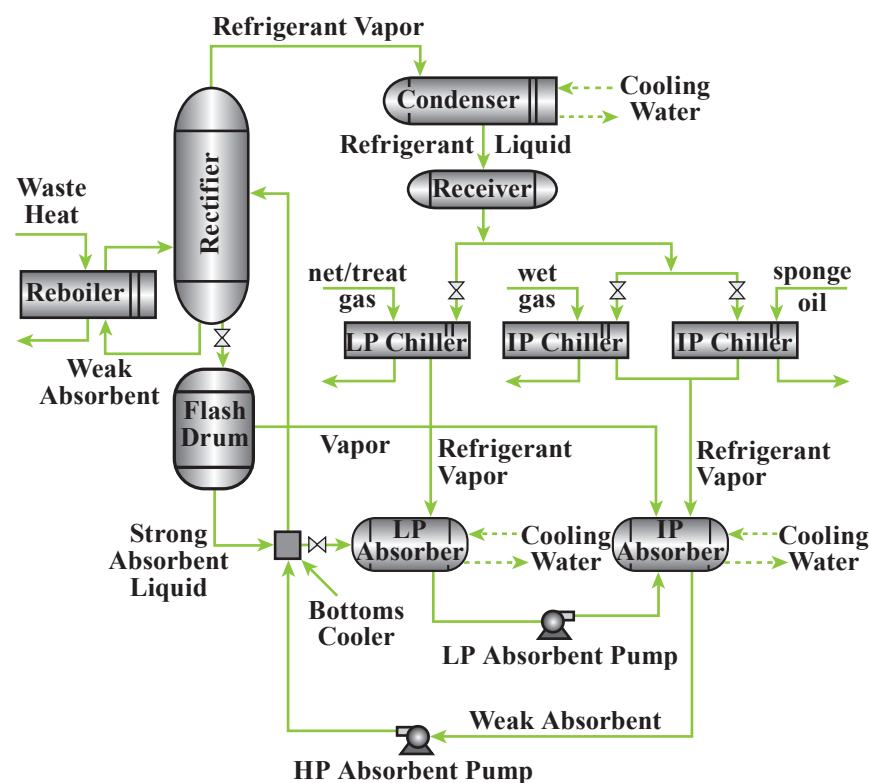
Absorption Heat Pump/Refrigeration Unit

IMPACTS

Advanced Water Ammonia Absorption Cooling Finds Profitable Application in Refinery Operations

Refineries usually prefer ambient cooling with cooling towers because refrigeration systems cost more initially, create headaches in operating and maintaining compressors, and significantly increase the demand for electricity. With assistance from ITP and a grant from the Inventions and Innovation Program, the Energy Concepts Company developed an advanced ammonia refrigeration unit powered by waste heat. It overcomes the disadvantages of a refrigeration system. It recovers fuel from reformer waste gas and raises the capacity of a catalytic cracker. The unit debottlenecks the net gas compressors in a cracker. The inlet vapors are cooled, which increases the compressor capacity.

A commercial unit operating in Commerce City, Colorado, is providing up to 265 tons of refrigeration capacity to refrigerate the reformer plant net gas/treat gas stream and is recovering a net 45,000 barrels/year of gasoline and LPG. The 290°F waste heat content of the reformer reactor effluent powers the unit. The absorption cooling system is directly integrated into the refinery processes and uses enhanced, highly compact heat and mass transfer components. The refinery's investment was paid back in less than 2 years as a result of increased recovery of salable product, which was formerly flared. It is important to note that the recent increase in fuel prices has lowered this system's payback considerably.



Absorption Heat Pump/Refrigeration Unit

Overview

- ◆ Developed by Energy Concepts Company
- ◆ One commercial unit installed at a refinery in 1997

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
2.23	0.306

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.002	0.178	0.047	6.66

Applications

- ◆ Resource recovery in the petroleum refining and chemical industries
- ◆ Refrigeration and space conditioning for commercial and industrial facilities

Capabilities

- ◆ Water/ammonia absorption cycle can be powered from any heat source.
- ◆ Can deliver temperatures as low as -50°F.

Benefits

Profitability

Reduces energy intensity for a refinery and increases throughput for fluid catalytic crackers that have a bottleneck due to an overloaded wet-gas compressor. Applying refrigeration to refinery fuel gas header streams can recover millions of dollars worth of gasoline and liquefied petroleum gas (LPG) annually.

Advanced Membrane Devices for Natural Gas Cleaning

IMPACTS

New Membrane Cost Effectively Upgrades Sub-Quality Natural Gas

Carbon dioxide (CO₂) is a common impurity that must be removed in natural gas to improve the gas's heating value or to meet pipeline specifications. Hydrogen sulfide (H₂S) often prohibits natural gas from being used to generate power and drive compressors at remote locations such as oil and gas production sites. Production companies are faced with choosing among shutting in a well, overhauling engines frequently, or dealing with logistical challenges associated with routing other fuels to the site.

With DOE support, Air Products & Chemicals, Inc., through its Advanced Membrane Devices project, developed and successfully commercialized PRISM® membranes for upgrading sub-quality natural gas. These semi-permeable polymeric membranes can be used as gas scrubbers for natural gas, removing CO₂ and H₂S from natural gas.

PRISM membranes, based on simple process designs, provide a low-cost alternative to traditional amine systems that are used to upgrade natural gas. The membranes can also be used as a bulk-removal device to minimize the size of an amine system. The benefits become even more pronounced as the industry produces natural gas from very remote locations. Fuel-gas conditioning systems that incorporate PRISM membranes provide oil and gas production companies with an economical solution to an otherwise often enormous problem. The membrane device can be used to make low-grade natural gas with high CO₂ and H₂S content into a pipeline-grade gas for domestic and industrial consumption.

Overview

- ◆ Developed by Air Products & Chemicals
- ◆ Commercialized in 2001
- ◆ 98 CO₂-removal units operating in the United States in 2004

Applications

- ◆ Recovers CO₂ from associated gas in enhanced oil recovery programs
- ◆ Removes acid gas from natural gas

Capabilities

Can reduce impurities to allow natural gas to meet pipeline specifications.

Benefits

Environmental Quality

The PRISM membranes do not use any hazardous chemicals such as amines, which can cause environmental complications.

Ease of Installation

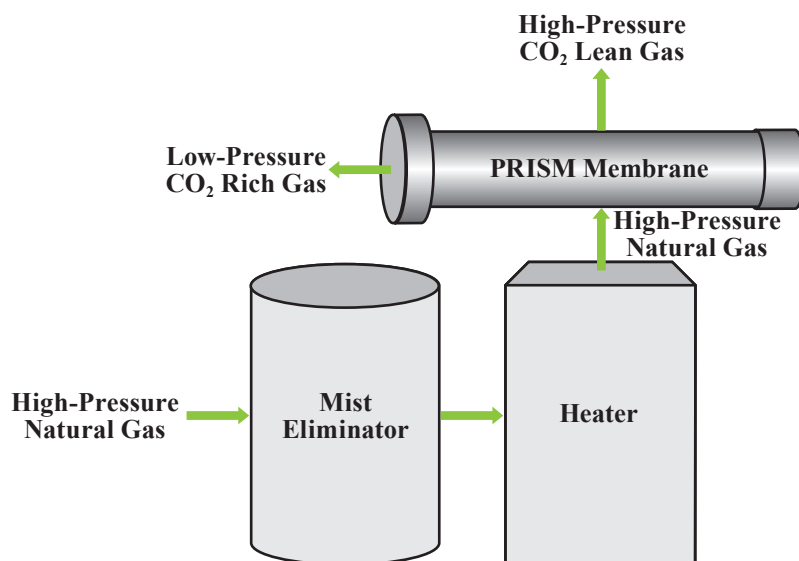
Units are lightweight and compact, thus facilitating their transportation and installation.

Profitability

The membranes are ideal for remote locations with limited utilities and sour natural gas.

Reliability

No moving parts mean minimal maintenance costs.



CO₂ Removal Process Using the PRISM Membrane System

Brick Kiln Design Using Low Thermal Mass Technology

IMPACTS

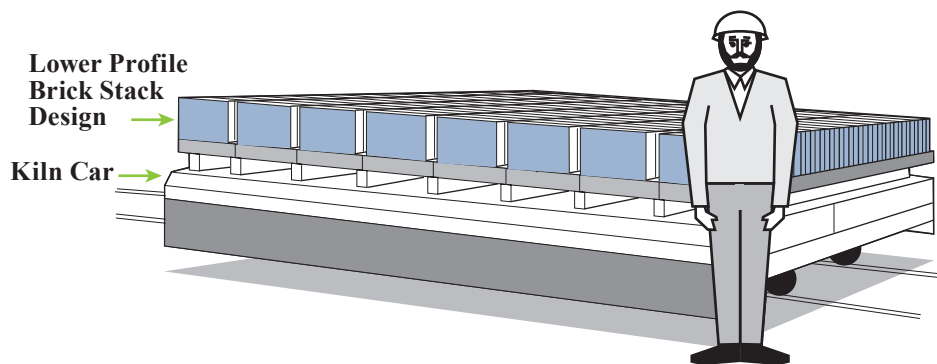
Innovative Brick Kiln Using Low Thermal Mass and Low-NO_x Technologies

Swindell Dressler and Pacific Clay Brick have successfully developed and demonstrated, using a NICE³ grant, a tunnel-kiln design with a low thermal mass. This new brick kiln uses three technical innovations: ceramic-fiber insulation in lieu of traditional refractory brick, a lower profile stack design for brick kiln cars, and more but smaller low-NO_x gas burners. These innovations result in a reduction in natural gas usage of 35% compared to a conventional kiln.

Replacing traditional refractory brick with ceramic fiber insulation allows the new design to reach operating temperature in about 1 hour compared to 24 hours for traditional designs. Additionally, the ceramic-fiber bricks with a low thermal mass absorb less heat, so more heat is available to fire the bricks.

A lower profile stack design for the bricks on the kiln cars means that bricks are placed 4 to 5 layers high instead of 15 layers high with traditional kilns. This lower profile stack design allows for better heat penetration into the bricks and better process control.

Several process changes reduce NO_x emissions: lower kiln firing temperatures (2100°F versus 2250°F), newer high-velocity burners, and a fully automated Process Management System that will maintain set points, including furnace-zone and rapid-cool zone temperatures.



New Low Profile Brick Kiln Car

Overview

- ◆ Developed by Swindell Dressler
- ◆ Commercialized in 1996
- ◆ 2 units now operating

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.248	0.032

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.004	0.508

Applications

Brick and ceramic material kilns

Capabilities

- ◆ Uses low thermal mass kiln design to reduce energy consumption and increase throughput.
- ◆ Has better process control with better placement of more but smaller burners.
- ◆ Employs low-NO_x burners.

Benefits

Productivity

Reduces time to preheat kiln to operating temperature from 24 hours to 1 hour.

Waste Reduction

Reduces rejection rate due to better process control and even heat distribution.

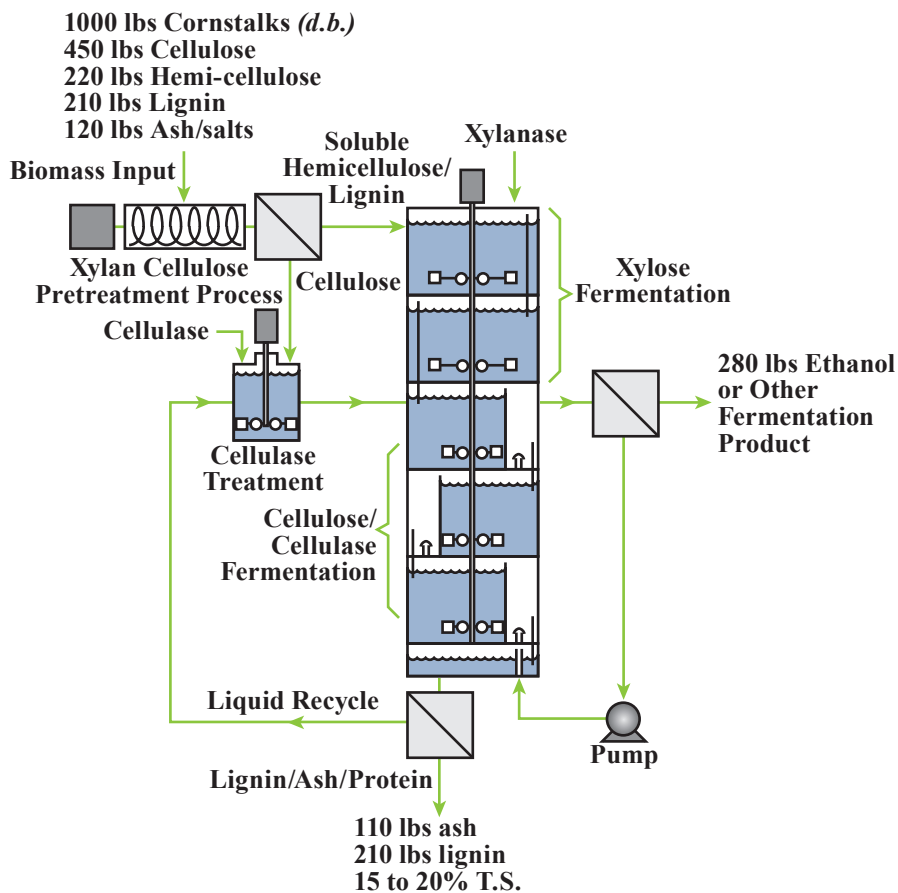
Continuous Cascade Fermentation System for Chemical Precursors

IMPACTS

Continuous Cascade Fermentation System Increases Yields and Cuts Process Time for Converting Carbohydrates to Ethanol and other Chemical Precursors

With assistance from DOE's Inventions and Innovation Program, Bio-Process Innovation (BPI), Inc., developed a proprietary cascade reactor for ethanol production from carbohydrate feedstocks that eliminates the need to fill, empty, and wash a fermenter as part of a batch operation. Feed is introduced continuously into the first of three to five stirred reactors placed in series, with the outflow of one reactor flowing into the next reactor. The effluent from the reactor is then taken to a low-energy solvent absorption/extractive distillation system for separating and purifying ethanol. Separating the ethanol as it is produced increases the rate of ethanol production. BPI, Inc., also developed a highly flocculent yeast that further speeds the reaction of sugar to ethanol by maintaining cell densities of over 30 grams/liter. Continuous operations can more than double the fermentation capacity of a batch ethanol facility.

A five-stage unit of 40,000 gallons reactor volume operated at an Iowa site from 1996 to 2004 on waste starches/sugars. It produced about 1 million gallons of ethanol per year. Two small plants in Wisconsin and Minnesota were using this technology to convert permeate mother liquor to ethanol.



*Commercialized Fermentation Technology Applied
to Emerging Concept of Biomass Fermentation*

Overview

- ◆ Commercialized by Bio-Process Innovation (BPI), Inc. in 1996
- ◆ Over 8 years operational experience
- ◆ 1 United States installation operated in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.814	0.037

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.0	.782

Applications

Converting carbohydrate feed stocks, which comprise 65% of municipal solid waste, to ethanol or other chemical precursors

Capabilities

- ◆ Continuous rather than batch system allows quick and complete saccharification and fermentation of feedstocks and removal of ethanol into a gas phase as it is produced.
- ◆ Uses abundant cellulosics as a feedstock for alternative chemical precursors.

Benefits

Productivity

Conventional reactor processing time of 36 to 48 hours is reduced to 24 hours or less. Dramatically improves throughput by maintaining a high cell density in the reactors and operating continuously.

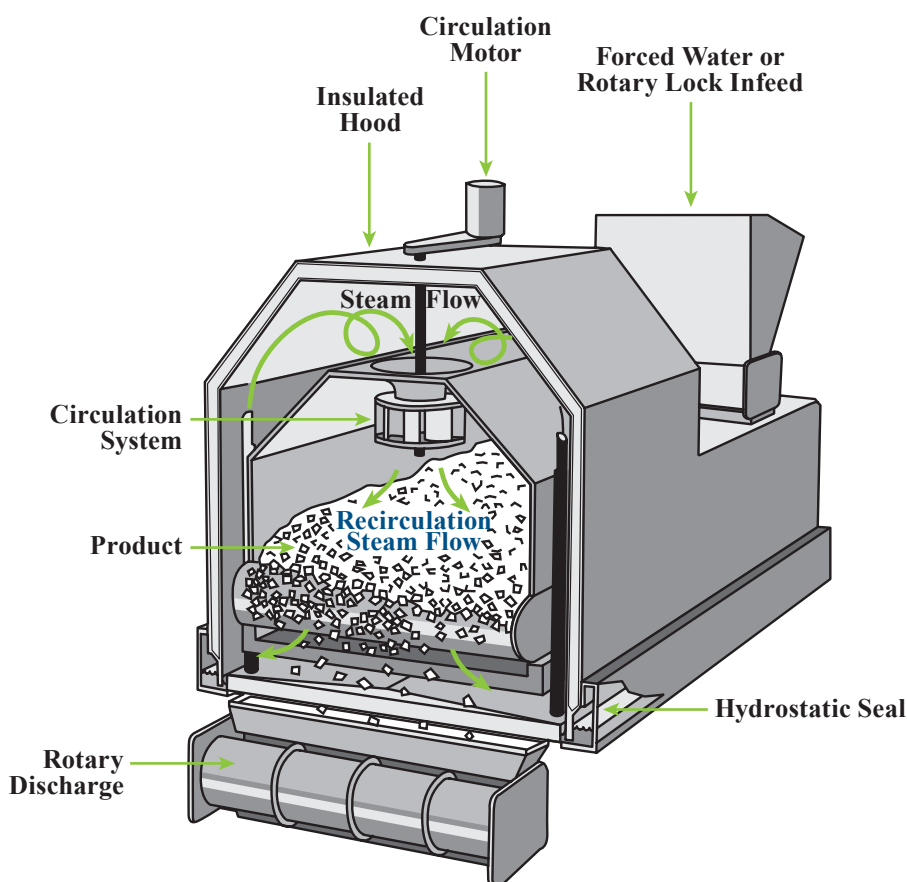
Profitability

Lowers the cost of producing ethanol or other fermentation chemicals from carbohydrates by cutting production labor. Can be retrofitted on fermenters currently in use in batch-process ethanol production facilities.

New Blanching System Increases Productivity While Saving Energy

This innovative blanching technology recirculates and reuses steam, dramatically reducing water and energy use, and wastewater production. Key Technology, Inc., using a NICE³ grant, developed and demonstrated the energy-saving and waste-reducing Turbo-Flo® Blancher/Cooker System. The Turbo-Flo system is a revolutionary advance in blanching and cooking technology. Traditional blanchers use a tremendous amount of steam or hot water (200-212°F) that is energy intensive, often overcooking the product being blanched. There are currently more than 60 Turbo-Flo units operating with energy savings of more than 70% and improved product quality.

In addition to the blancher innovations, Key Technology also collaborated with Washington State University to develop a lipoxygenase enzyme sensor that is capable of reducing blanch times in several types of vegetables. While the sensor was demonstrated in bench-scale tests, it is still in a developmental stage and not yet available commercially. When the development is complete, the new sensor will provide even more energy savings by further optimizing the blanching process.



Cut-Away of the Turbo-Flo Blancher

Overview

- ◆ Developed by Key Technology, Inc.
- ◆ More than 62 units operating in the food processing industry

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.007	0.001

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.0	0.026

Applications

Processing of fruits, vegetables, and potatoes for shelf-life protection

Capabilities

- ◆ Reduces product-to-steam ratio.
- ◆ Saves approximately 70% of energy use.
- ◆ Eliminates process wastewater.

Benefits

Environmental

Wastewater is virtually eliminated with the Turbo-Flo. Estimated water savings from the use of this system are over 3.8 million gallons of water per year per unit.

Productivity

With efficiency gains, shorter cook and blanch times increase yields by 2% to 5% over conventional water blanchers.

Quality/Process Improvement

The Turbo-Flo system improves nutrient retention, taste, and appearance through shorter cook cycles and takes up only about 60% as much floor space as conventional blanching/cooking equipment. The Turbo-Flo system ensures more even cooking temperatures, and provides consistent product definition and quality.

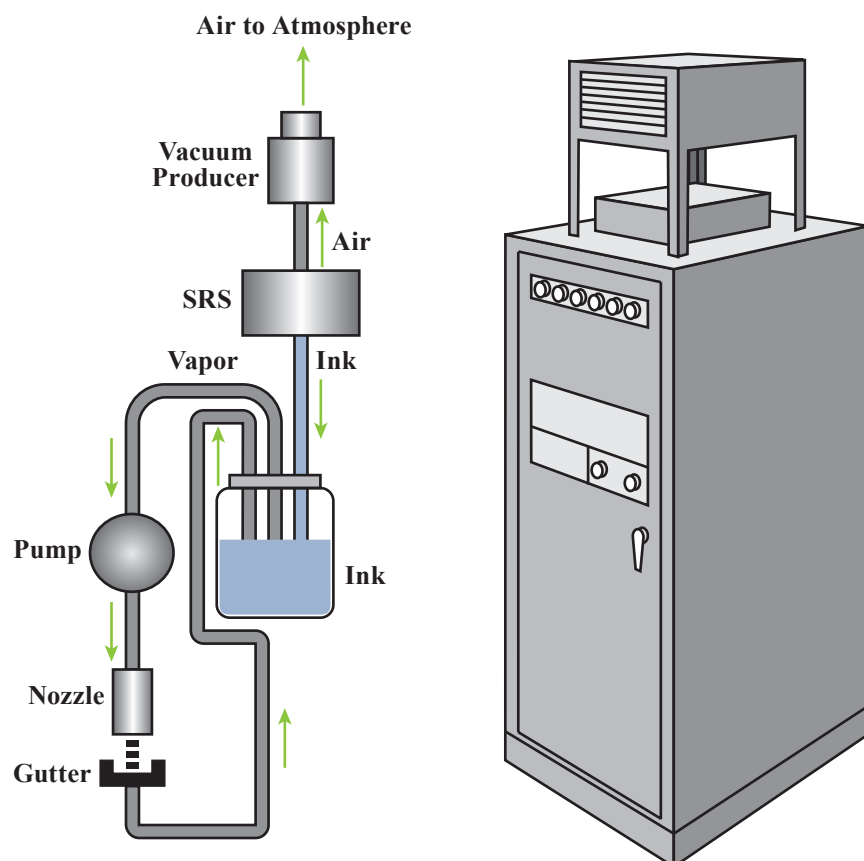
IMPACTS

Ink Jet Printer Solvent Recovery System for Commercial Printing Applications Reduces Emissions

Quad/Tech International (QTI) developed a new solvent recovery system (SRS) for commercial printers. This system was demonstrated using a NICE³ grant. The SRS captures and reuses 60% to 70% of the volatile organic compounds (VOCs) associated with the printing process. The SRS can also reduce the amount of ink and solvent that would be lost as vapor by up to 50% on average, resulting in a significant reduction in emissions. Additionally, because less fluid is used, the fluid containers do not have to be changed as often, resulting in labor savings and less downtime on the production line. Lastly, reduced VOC and acetone emissions make the work environment healthier for employees.

The SRS consists of a closed-loop ink supply tank that directs solvent vapors discharged from the tank through a vent tube. The vent tube is connected to a condenser that cools the vapors, condensing nearly all the solvent. The vapors are then returned via the vent to the ink supply tank.

QTI has over 625 of these units currently in operation. Energy savings result from the reduced need to manufacture the solvent, manufacture the plastic containers that the solvent is shipped in, and transport the solvent.



The Quad/Tech Solvent Recovery System (SRS)

Overview

- ◆ Developed by Quad/Tech International (QTI)
- ◆ Commercialized in 1997
- ◆ 637 units operating

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.345	0.051

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.021	1.03	0.769	93.9

Applications

Capturing and reusing VOCs in commercial printing processes

Capabilities

- ◆ Recovers 60% to 70% of VOCs.
- ◆ Reduces ink and solvent loss by vapor capture.
- ◆ Increases compliance capability with environmental regulations governing VOC release.

Benefits

Productivity

Recovers ink and solvent lost as vapor, resulting in less downtime to replace depleted fluid reservoirs.

Use of Raw Materials/Feedstocks

Recovery of ink and solvent reduces make-up streams, saving ink and solvent feedstocks.

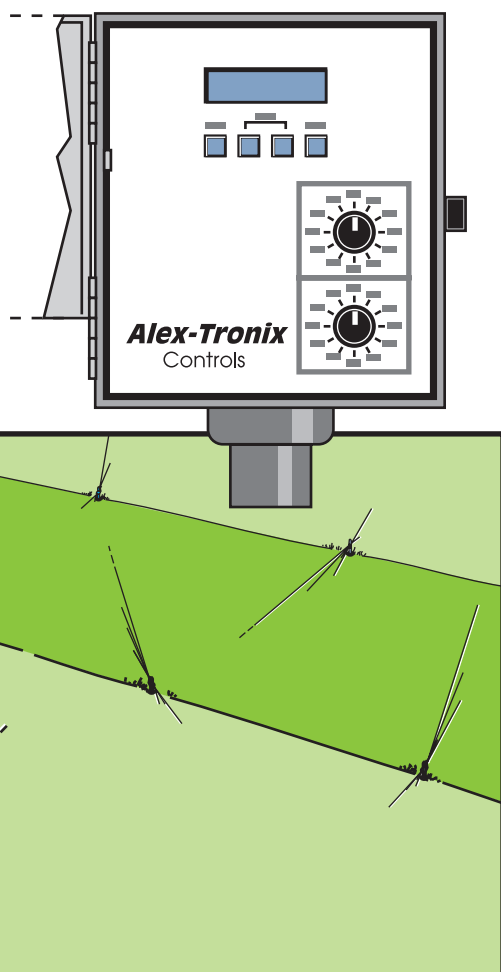
Irrigation Valve Solenoid Energy Saver

IMPACTS

New Solenoid Controller for Irrigation Valves Saves Energy

A battery operated, multi-station, irrigation valve control unit was developed with funding from DOE's Inventions and Innovation Program. The Battery Control System (BCS) uses low-powered, latching solenoid controllers with internal batteries that last for a minimum of 5 years.

Automated irrigation systems with latching solenoid controllers require a constant flow of electricity to keep the valves operating. A battery sends power surges to the solenoid as needed to open and close the valves. The BCS available from Alex-Tronix Controls uses the SWELL solenoid power saver. With the SWELL unit, the inrush and holding current requirements are only about 10% that of most other solenoids. The SWELL's greatly reduced inrush and holding current requirements allows valves to be operated at much longer distances. The BCS can operate valves reliably out to a distance of almost 20 miles. Other battery-powered controllers are limited in distance to about 1000 feet. Up to five valves can be operated simultaneously with a single irrigation controller. The solenoid coil never burns out because there is no power in the coil.



Battery Control System for Irrigation Valves

Overview

- ◆ Developed and being marketed by Alex-Tronix Controls
- ◆ Commercialized in 1999 with over 2700 units in the field
- ◆ Proven operation in laboratory and field tests

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.014	0.003

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.001	0.0	0.056

Applications

For sprinkler systems in medians, schools, shopping malls, golf courses, parks, agricultural and industrial applications

Capabilities

- ◆ Operates valves out to about 20 miles.
- ◆ Eliminates the energy and primary wiring needed to operate an irrigation system.
- ◆ Technology has 10 times the battery life and 100 times the operating distance of any other controller.

Benefits

Ease of Installation

Controllers can be installed anywhere. There is no need to install electrical meters or to use licensed electricians for installation.

Safety

There are no electrical safety concerns. Power surge and lightning-related problems associated with primary power leads are eliminated because there is no need for primary wiring.

Restaurant Exhaust Ventilation Monitor/Controller

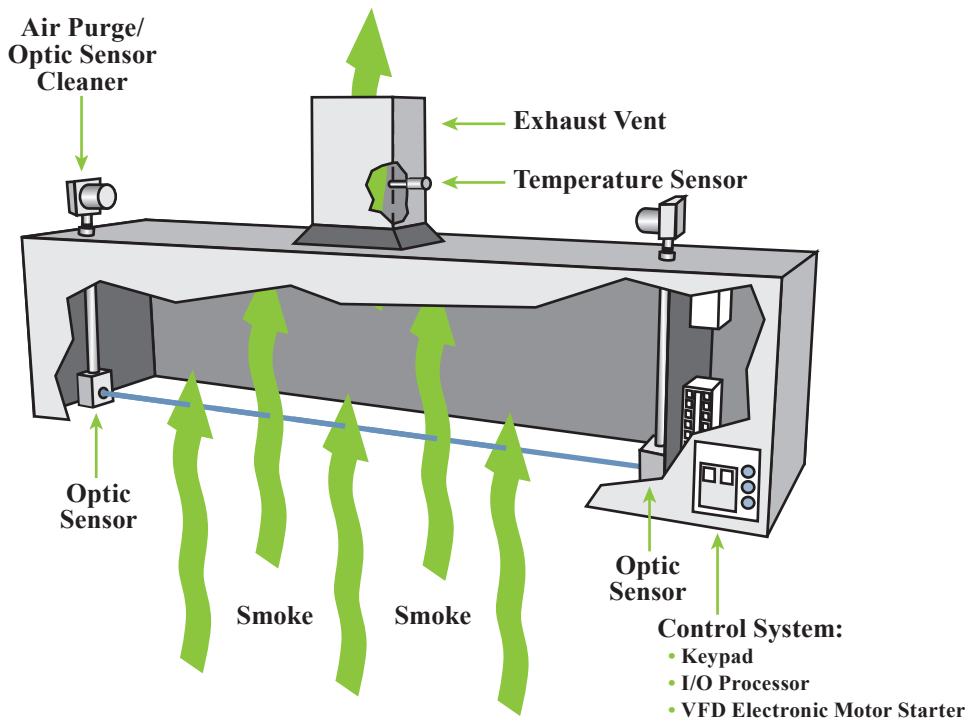
IMPACTS

New Kitchen Exhaust System Uses Variable Speed Controls to Save Energy

Typical exhaust hoods in restaurants operate at full speed all day long and sometimes all night long even when cooking is not taking place. With assistance from DOE's Inventions and Innovation Program, Melink Corporation developed a microprocessor-based controller for commercial kitchen ventilation systems. The controller optimizes system performance for four key parameters: kitchen comfort, fire safety, occupant health, and energy efficiency. The controller uses an intelligent code that continually analyzes an array of operational inputs and provides an output signal to variable-frequency speed drive (VFD) electronic motor starters, which then vary the speed of the exhaust and makeup fans.

The main control system includes a keypad that provides bypass capability and preset functions such as minimum fan speed, temperature span, and monitoring. The input/output (I/O) processor continuously reads inputs from the optic and temperature sensors that monitor heat and smoke levels from cooking activity. The air purge units prevent grease vapors from collecting on the optic sensor lenses to ensure trouble-free operation.

When cooking needs are low, the sensors prompt the processor to maintain low preset fan speeds, which provides fan motor energy savings. When the sensors identify smoke or temperature levels above preset limits, the processor prompts the electronic motor starter to increase the exhaust fan speed to accommodate increased ventilation needs. When cooking needs are reduced, the sensors prompt the processor to again reduce fan speeds to energy-saving levels.



The Melink Restaurant Exhaust Ventilation System

Overview

- ◆ Developed by Melink Corporation
- ◆ Commercialized in 1994
- ◆ Over 2700 units sold

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.605	0.236

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.001	0.051	0.038	4.64

Applications

Commercial kitchen ventilation systems for restaurants, schools, hospitals, hotels, and other institutions

Capabilities

- ◆ Monitors and reduces the fan speed during idle periods of kitchen activity to save energy.
- ◆ Provides sensors that monitor heat and smoke levels for safety.

Benefits

The main benefit of upgrading the hood system with variable-speed controls is energy savings. Other benefits include improved kitchen comfort, occupant health, and fire safety.

Stalk and Root Embedding Plow

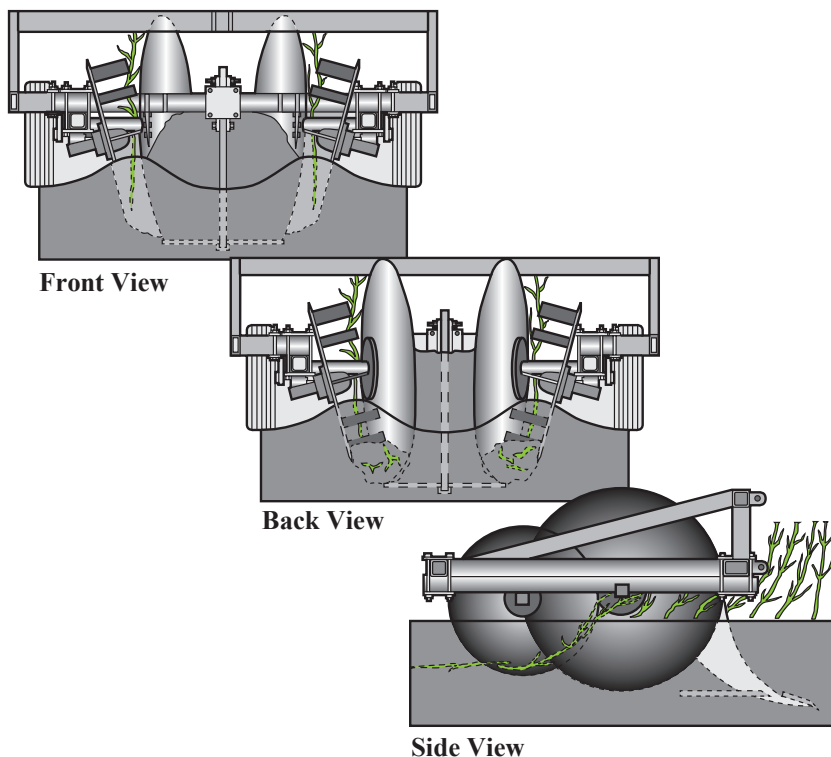
IMPACTS

New Stalk and Root Embedding Plow Prevents Post Damage and Saves Time in Preparing Fields

Disposing of cotton stalks and roots in the field after harvest is an energy-intensive operation. Nationwide, many cotton farmers use conventional tillage practices that involve shredding the stalks and making several tillage passes over the field to prepare a new seedbed. These tillage operations consume over one-half of farmers' annual fuel budget, and most farmers are frustrated with the high costs and time requirements. Over the last 50 years, farmers have tried several alternative tillage systems, all of which involve uprooting the cotton plants and mixing the crop residue into the soil. All uprooters have shortcomings, and none have gained wide acceptance across the Cotton Belt.

With assistance from DOE's Inventions and Innovation Program, the University of Arizona invented the Pegasus system—a stalk, root, and agricultural debris-burying tillage machine suited for burying row crops, especially cotton, to prevent pest damage and prepare fields for crops. The rapid plow-down design is a breakthrough in cotton tillage. A narrow moldboard plow opens a deep trench in the soil next to the crop row. Then a “stuffer disk” inserts the roots and stalks into the deep trench. The whole stalks are buried in a “rope” bundle under the bed where they decompose. The machine also forms new beds, leaving the field ready for the next crop.

Rigorous research by the United States Department of Agriculture indicates dramatic savings in cost, time, and energy. There are no adverse effects. Yields with the Pegasus have ranged from the same as conventional methods to 12% greater than conventional methods.



Stalk and Root Embedding Plow

Overview

- ◆ Invented by the University of Arizona and being sold by the Rome Plow Company
- ◆ Commercialized in 1996
- ◆ 73 units operating in 2004

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.102	0.020

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.0	0.0	0.421

Applications

- ◆ Breakthrough tillage technology for agriculture
- ◆ Cotton and other row-crop tillage

Capabilities

- ◆ Operates valves out to about 20 miles.
- ◆ Deeply entrenches whole stalks and roots into soil in one pass, eliminating need to shred stalks.
- ◆ Plows 7 acres/hour at 4.0 to 4.5 mph.

Benefits

Air Emissions Reductions

Eliminates stalk shredding, a large contributor to dust emissions, and cuts engine air emissions by 70% compared with conventional tillage practices.

Productivity

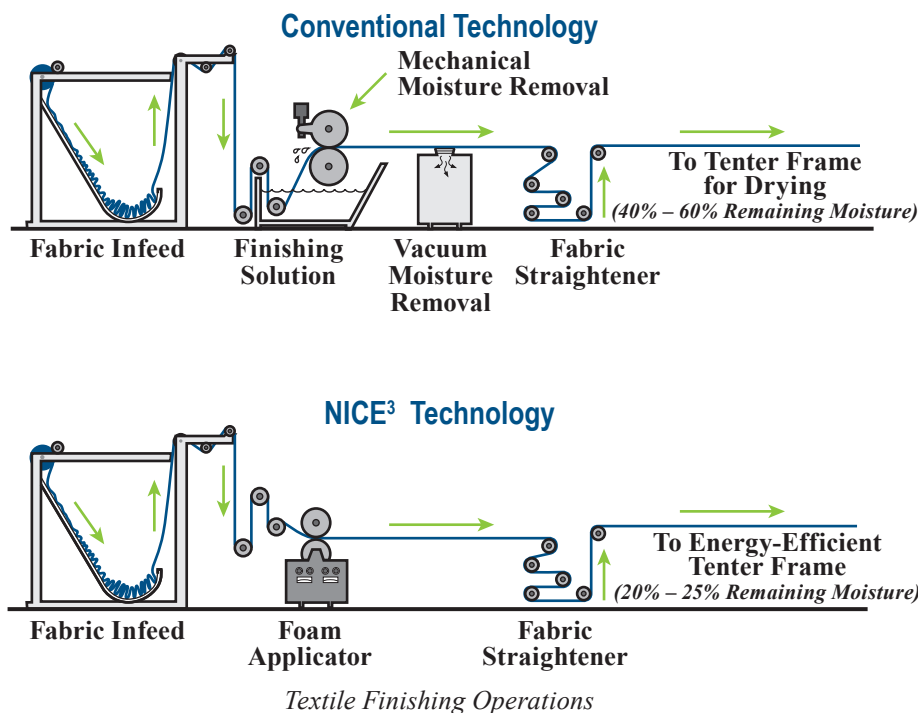
Requires 75% to 80% less time to dispose of crop residue and prepare a new seedbed compared with conventional tillage practices. Saves 4 to 7 repeat passes of tillage machinery to work and prepare fields. Results in cost savings of \$50/acre compared with conventional tillage practices.

IMPACTS

New Process Increases Productivity and Energy Efficiency in Fabric Finishing

The United States textile industry consumes large amounts of energy and water in finishing fabrics. The finishing operation is the final step in producing fabrics and typically imparts the aesthetic and physical properties required for various fabric uses. Using conventional technology, fabric finishers immerse fabric in a solution of finishing chemicals diluted in water. Once saturated, the fabric is removed, and excess moisture is squeezed out mechanically. The moisture is further reduced by a vacuum system before the fabric is directed to fabric drying equipment called the “tenter frame.” The tenter frame removes the remaining moisture by processing the fabric through a series of nozzles that expose it to hot air. Because of the relatively high moisture content, the fabric finishing process has been very energy intensive.

With assistance from a NICE³ grant, Brittany Dyeing and Printing demonstrated a new process for finishing textiles. In the new process the finishing chemicals are diluted with air instead of water and applied to the fabric as foam. No additional mechanical or vacuum moisture removal is necessary; thus, saving energy and water. The moisture content of the fabric is cut in half, allowing a new energy-efficient, high-speed tenter frame to be used. This new process increases the productivity of the finishing line by more than 100%.



Overview

- ◆ Commercialized in 1999
- ◆ Demonstrated savings continue at Brittany Dyeing and Printing Corporation

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.136	0.023

Emissions Reductions

(Thousand Tons, 2004)

Particulates	SO _x	NO _x	Carbon
0.0	0.002	0.003	0.397

Applications

Process applies to the textile finishing industry

Capabilities

- ◆ Replaces traditional water-based textile finishing applications.
- ◆ Reduces the moisture content of fabric from finishing by more than 50%.
- ◆ Increases production capability by over 100% through higher production speeds.

Benefits

Energy Savings

Energy savings result from application of chemicals in a foam media rather than liquid – this reduces the moisture content; thus, less energy is needed to dry fabric.

Environmental

In the new system, finishing chemicals are diluted with air instead of water; thus, less water is used and less wastewater discharged.

Productivity

Reduced moisture content allows for higher production rates (over 100% increase in production capability).

Plastics from Renewable Resources Offer Significant Commercial and Environmental Benefits

Each year, 60 billion pounds of thermoplastics are produced from imported and domestic oil to make industrial and consumer products. Because oil is an increasingly limited resource with negative impacts on the environment, reducing dependence on oil in all areas is important, including product manufacturing.

Poly lactide (PLA), derived from annually renewable corn, can be used in place of petroleum-based thermoplastics in many applications such as compostable packaging, film, and fibers for apparel, carpeting, and other fabrics. With financial assistance from DOE, the National Renewable Energy Laboratory along with Cargill Dow LLC and the Colorado School of Mines developed and refined a process to use PLA in manufacturing. Substituting PLA for petroleum-derived polymers reduces fossil energy use by 20% to 50%. The PLA plastics also result in reduced emissions of CO₂ compared with the petroleum-based thermoplastics. Projections are that 10% of the U.S. nonrenewable plastics packaging can be replaced with polylactide polymer.

This project assisted in expanding the PLA market by developing two new processing technologies. Both technologies yield semi-crystalline PLA articles that have improved physical properties. Other project tasks helped to better understand the relationship between polymer molecular structure and physical properties, which is useful information for improving process control.

Benefits

Energy Savings and Pollution Reduction

Compared with producing products from petroleum, corn-based PLA consumes 20% to 50% less energy in the form of fossil resources. Additionally, the carbon comes from plants that extracted CO₂ from the atmosphere, thereby emitting less CO₂ than petroleum-based products.

National Security

Using U.S.-grown corn instead of oil reduces the nation's dependence on foreign resources and oil to produce necessary products such as clothing and food packaging.

Overview

- ◆ Research being led by NREL with Cargill Dow LLC and Colorado School of Mines
- ◆ Commercialized in 2003
- ◆ Produced at Cargill Dow's Blair, Nebraska, facility with a capacity of 300 million pounds per year

Energy Savings

(Trillion Btu)

Cumulative through 2004	2004
0.033	0.018

Emissions Reductions

(Thousand Tons, 2004)

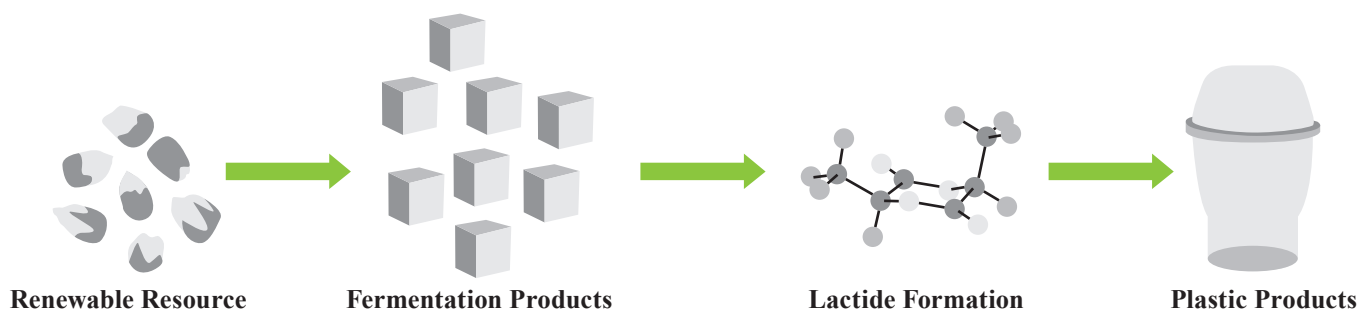
Particulates	SO _x	NO _x	Carbon
0.0	0.011	0.003	0.394

Applications

Plastics and textile industries, replacing certain packaging, films, and fibers used for apparel, carpeting, and other fabrics

Capabilities

- ◆ Competes in a market based on price and performance, with a better environmental profile than today's plastics.
- ◆ Currently can replace 10% of packaging with PLA, with more research being conducted to infiltrate the market further.



Process for Producing Plastic Using Renewable Resources